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WEEKLY 5 March 2022

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INVASION**

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The nuclear question
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Life on Earth

Over 3 billion years in the making, the latest *New Scientist Essential Guide* is a sweeping survey of the history of life on our planet, the wonders of biodiversity today – and the threats it faces from human activity. This is the 11th edition of our Essential Guides, which you can buy individually online or take out a subscription to get them delivered to your door.

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Podcasts

Weekly

The team unpacks two of the consequences of Russia's war in Ukraine: the way it will affect western Europe's reliance on Russian oil and gas, and the threat of Russian cyberattacks. Plus, with the last remaining covid-19 restrictions scrapped in England, we are joined by healthcare expert Christina Pagel to ask if this was the right decision. And the team discusses the intelligence of orangutans, based on their ability to use and make tools.

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Podcast



CHRISTOPHER CHAN/GETTY IMAGES

Smart ape A new study shows orangutans spontaneously use tools

Discovery Tours



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Timeless beauty See Prague's world-famous astronomical clock

Video

Evolving robots

These days, robots have impressive abilities. But there are some jobs – say, mapping a distant asteroid – for which we can't easily predetermine what robots should be capable of. One solution is to use machines that can evolve, adapting and reproducing to generate better versions of themselves. Our latest video looks at these evolving robots.

youtube.com/newscientist

Newsletter

Fix the Planet

Get Adam Vaughan's newsletter on the climate emergency and its solutions delivered free to your inbox each week. Adam often considers technological fixes, but in the latest issue, he takes a careful look at the role of behaviour change and social science in getting us to net-zero emissions.

newscientist.com/fix-the-planet



Those of you who have been *New Scientist* readers for more than two years will know that live events are a thrilling part of what we do. The most exciting of all our events is New Scientist Live, our annual show in London, featuring riveting talks on multiple stages and a huge exhibition floor to explore.

Because of covid-19, we have only done online events since March 2020. But we know many of you have missed the buzz of being there in the flesh, so I am delighted that there will be two big in-person New Scientist Live events in the UK this year.

We will be back in London this October with our flagship event at the ExCel Centre. But first, our festival of ideas and discovery will be setting up its stall at Manchester Central on 12 to 14 March, and it's not too late to get tickets.

With fantastic speakers ranging from geneticists Turi King and Giles Yeo to physicists Jim Al-Khalili and Alex Keshavarzi, there will definitely be something there for everyone. And the good news for those who don't live in the UK or can't get to Manchester is that we will also be live-streaming the event all weekend.

So, whether in person or online, I do hope you can come join us at the world's greatest science festivals this year!

Emily Wilson

New Scientist editor

Cut through with conviction



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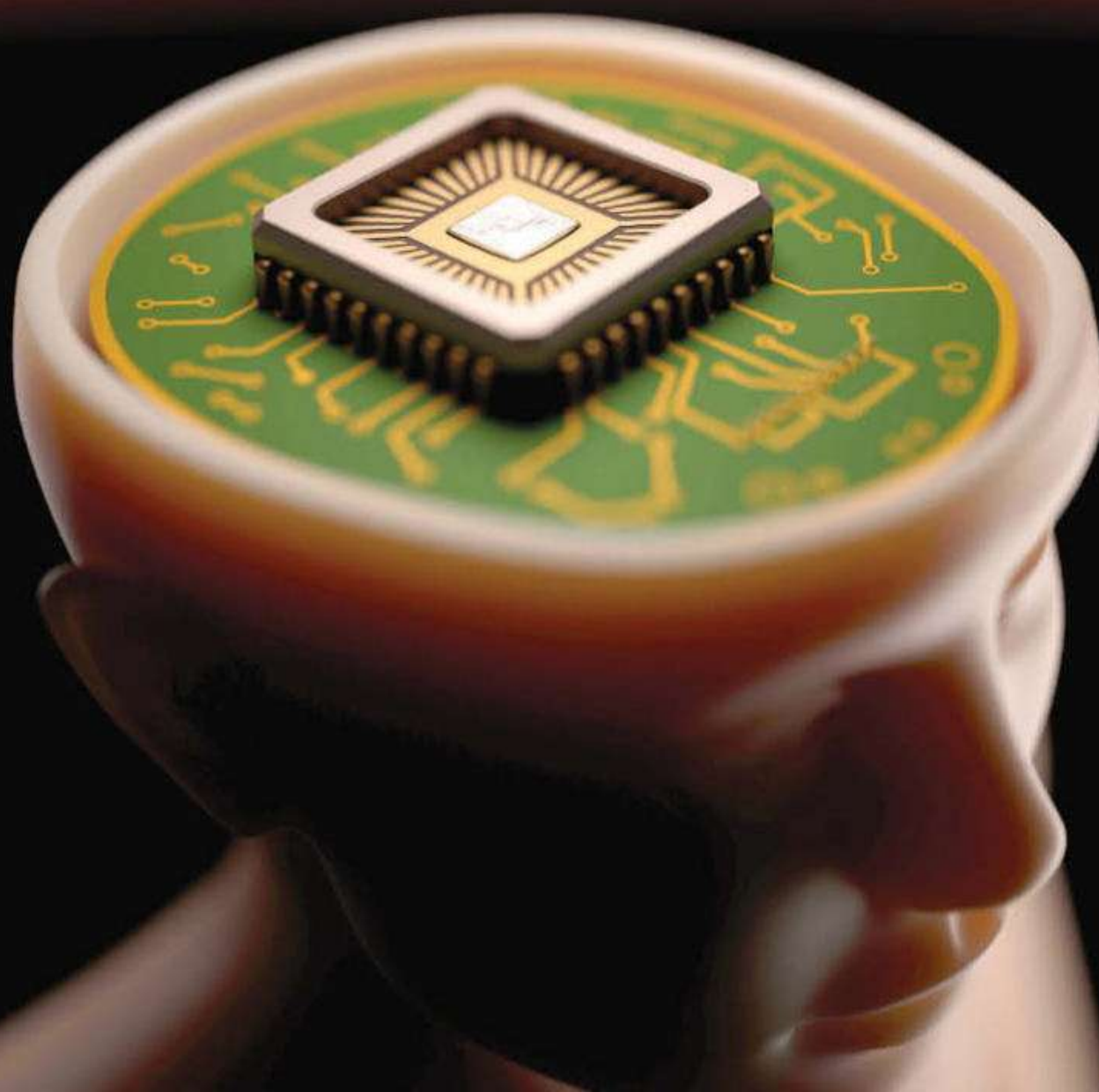
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Chemical solutions

Chemistry contributes to many environmental woes, but it can help fight them too

PERFLUOROOCTANESULFONIC ACID might not roll off your tongue, but you almost undoubtedly have some of it inside you. Once widely used as a water-repellent coating for clothing and fabrics, “PFOS” is now notorious as a non-biodegrading “forever chemical” that builds up in the environment, our water supply and eventually us.

The world is finally coming to terms with the legacy of our indiscriminate development and use of chemicals over the past half-century and more. Last year, the UN declared chemical pollution a third great planetary crisis, alongside climate change and biodiversity loss.

These are welcome developments, as are earlier steps, such as the agreement in 2001 of the Stockholm Convention on Persistent Organic Pollutants and

subsequent actions to expand its scope, under which many of the most harmful environmental chemicals, among them PFOS, are now targeted for elimination.

For many, “chemistry” and “chemicals” have themselves become dirty words. According to Google’s Ngram Viewer, which tracks words in published materials,

“We should be wary of throwing away the chemical baby with the polluted bathwater”

use of “chemophobia” was falling sharply until 2011, but has since been creeping upwards again.

Yet chemistry has been good to us, paving the way for everything from life-saving drugs to invaluable technologies such as touchscreens.

Today, it is also helping to clean up the environment, for example by developing liquid solvents to absorb carbon dioxide from the atmosphere, a crucial part of our quest to hit net-zero emissions.

As our report on seven particularly future-facing chemical innovations makes plain (see page 38), chemistry has plenty more green potential, too, for instance through creating less environmentally damaging batteries and harnessing the power of photosynthesis to boost the clean-energy transition, or righting the wrong of persistent plastic pollution by developing infinitely recyclable polymers.

So we should be wary of throwing away the chemical baby with the polluted bathwater. Chemistry has all too often been part of the problem – but used right, it can be part of the solution, too. ■

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For more information and to book your place visit:

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MARK FREESTONE, NIAMH NIC DAEID AND VAL MCDERMID



REUTERS/ANTONIO BRONIC

A Ukrainian soldier at the Russia-Ukraine border on 23 February

Nuclear weapons

The ultimate warning

With the invasion of Ukraine ongoing, there is a real risk of Russia using a nuclear weapon as a show of force, finds **Matthew Sparkes**

NUCLEAR conflict remains a distinct but remote possibility as a result of the war in Ukraine, analysts warned as *New Scientist* went to press. Russian president Vladimir Putin is in a vulnerable and unpredictable position as he contends with a lacklustre economy, growing dissent among his citizens and, now, the potential for military defeat in Ukraine.

On 27 February, Putin raised Russia's nuclear readiness system level by ordering his forces into a "special regime of combat duty". Patrick Bury at the University of Bath, UK, says this announcement

was unusually vague, unlike the typical nuclear deterrence strategy of acting clearly and transparently as a warning to others. He and fellow academics and analysts assumed the country would have been at level 2 of Russia's four-level system already, given the situation in Ukraine.

Putin's announcement is being widely interpreted as a move from level 1 (stood down) to level 2 (ready to accept an order to fire). Bury believes we are closer to nuclear conflict now than at any point since the cold war tension of the 1980s. "Putin has poked a

sleeping giant," he says. "The West has responded massively."

This response includes Western nations sending weapons and aid to Ukraine, while strong economic sanctions from around the world are piling on the pressure against Putin. If Russia's invasion now fails, he could be removed from power or even killed in a coup, which Bury warns is a situation that backs Putin into a corner.

"In terms of military action, I think what we've seen so far is fairly limited. Russia is going to get heavy next"

"In terms of military action, I think what we've seen so far is fairly limited. I think they're going to get heavy next. And I think we need to prepare for far worse casualties," says Kenton White at the University of Reading, UK.

Russia may already have escalated its use of weaponry, with Ukraine reporting strikes using thermobaric weapons, which suck in oxygen to boost their explosive potential, and cluster bombs.

Bury puts the odds of a nuclear detonation as a result of this crisis at 20 per cent, but points out that it need not lead to all-out nuclear war. Instead, we could see a low-yield device used against the military in Ukraine or a device detonated at sea as a show of force.

"There's a lot of talk about rationality of action when you're discussing nuclear deterrence," says White. "Well, President Putin has a rationality all of his own." ■

Health

Humanitarian crisis in Ukraine

People in Ukraine face a loss of healthcare and clean water that could cause a rise in infectious disease, reports **Clare Wilson**, with some hospitals already out of oxygen

AID agencies have warned of a humanitarian emergency following Russia's invasion of Ukraine, with death and disease likely to result from a loss of health services and the mass migration of refugees, in addition to direct loss of life from military attacks.

More than half a million people have fled Ukraine and many are on the move within the country. The United Nations has said if the war escalates, up to 4 million Ukrainians, about a tenth of the population, may become refugees. "We're seeing significant displacement," says a spokesperson for the International Committee of the Red Cross (ICRC). "This brings increased levels of trauma, suffering and family separation."

Refugees and internally displaced people tend to have worse health due to crowded and poor living conditions leading to the spread of infectious diseases, for instance.

Hospital care is being jeopardised by a lack of power and medical supplies, including oxygen, demand for which has been increased by the covid-19

pandemic. Like most countries in Europe, Ukraine is currently on the downward slope of a recent high spike of covid-19 cases caused by the omicron variant, with about 1700 people thought to be in hospital because of the disease.

The World Health Organization said on 27 February that most hospitals were likely to use up their oxygen supplies within

Okhmatdyt children's hospital in Kyiv during Russian attacks



AYTAC UNAL/ANADOLU AGENCY VIA GETTY IMAGES

the next 24 hours, with some having already run out. Trucks are unable to move oxygen supplies from manufacturing plants to hospitals across the country. Several oxygen manufacturers face shortages of the mineral zeolite, needed for its production, which is mainly imported.

In the Donetsk region in the east, a million people are currently without access to clean water because two major water pumping stations have been affected by the attack, says the ICRC. The charity

has been supplying clean water to Dokuchaevsk hospital and municipal authorities. "Where clean water is lacking, infectious diseases and health problems are never far behind," says the ICRC spokesperson. "It is vital that civilian infrastructure must not be targeted."

The invasion will also disrupt normal public health programmes. In January, Ukraine launched a national campaign to boost uptake of the polio vaccine in children, after 20 cases were discovered last year in the city of Rivne and the Zakarpattia region in the west. Médecins Sans Frontières has also had to stop several public health programmes it was running in the country, including ones to combat HIV and tuberculosis, alongside basic healthcare provision.

On 27 February, Ukraine's Ministry of Health asked doctors and healthcare staff from other countries to come to Ukraine to help. "There is an urgent need for health care workforce to help both along the front and in the rear," the ministry said in a statement. ■

Space

European Mars rover may be delayed by Russian sanctions

RUSSIA'S invasion of Ukraine is having knock-on effects on space activities, with major uncertainties around an upcoming European Mars rover and the launch of satellites for UK company OneWeb, which is part-owned by the UK government.

One of the leading questions so far has been whether Russia's partnership with NASA on the International Space Station (ISS) can continue. NASA has so far said that the ISS won't be affected,

despite heavy sanctions for Russia from nations across the world. "The new export control measures will continue to allow US-Russia civil space cooperation," it said in a statement. "No changes are planned to the agency's support for ongoing in orbit and ground station operations."

Russia's previous invasions of Crimea in 2014 and Georgia in 2008 didn't result in a change to ISS operations, though on 24 February,

Dmitry Rogozin, head of the Russian space agency Roscosmos, tweeted a warning that US sanctions against Russia could "destroy" cooperation over the ISS.

There is much more uncertainty for European space projects. On 26 February, Rogozin announced that Russia would recall staff and no longer launch Soyuz rockets from the European Space Agency's (ESA) spaceport in French Guiana, probably

"Russia would get a lot of credibility from being involved in a European Mars mission"

delaying two Galileo navigation satellites, due to launch in April, and possibly the Euclid space telescope, set to blast off in February 2023.

Russia also launches European missions from its Baikonur spaceport in Kazakhstan, where ESA's flagship Rosalind Franklin rover, part of the ExoMars programme, is due to take off in September in search of life on the Red Planet. On 28 February, ESA announced that "the sanctions and the wider context make a launch in 2022 very unlikely", but it has yet to make a final decision.

"Russia would get a lot of credibility from being involved

European countries and companies are cutting energy ties to Russia

Adam Vaughan

THE European Union is expected to unveil a plan to reduce its dependence on Russian gas supplies, in the latest of a string of repercussions for the European energy landscape following Russia's invasion of Ukraine.

Oil and gas prices have spiked in the wake of the war. Russia is the world's second-largest oil

40%

Proportion of Europe's gas that comes from Russia

and gas producer, providing 17 per cent of gas output and 13 per cent of oil production globally in 2020. About 40 per cent of Europe's gas comes from Russia. In the UK, the figure was about 4 per cent in 2021.

The invasion has already made Germany pause Nord Stream 2, a major new gas pipeline from Russia, and order a review of how the country secures its energy. Russian oil and gas has continued flowing since the invasion began. But experts say European countries need to be prepared for the possibility of supplies

being halted, despite the financial hit Russia would take.

"The biggest leverage [Russian president Vladimir] Putin has over Europe's head is the ability to turn off the gas," says Sony Kapoor at the European University Institute in Italy. Contingency planning is under way and energy demand could be reduced to mitigate the impact of such a drastic move, he adds. But Kapoor says Russia turning off supplies would still be "a complete disaster for the European economy".

Germany is likely to diversify the sources of its gas imports by using more liquefied natural gas (LNG) transported by tankers, says Andreas Löschel at Ruhr University Bochum in Germany. German chancellor Olaf Scholz said on 27 February that the country would accelerate work on two planned LNG terminals.

Löschel thinks it is politically unlikely that Germany will delay its nuclear power phase-out, planned for the end of the year. However, Germany's economy minister, Robert Habeck, said on 27 February he wouldn't reject an



EVERETT NEWS/SHUTTERSTOCK

The Nord Stream 2 pipeline from Russia was halted by Germany

extension. Germany is expected to burn more coal as a short-term response to high gas prices, but Löschel thinks the country's long-term plan to bring forward an end date for using coal power from 2038 to 2030 remains safe.

The European Commission was due to publish a strategy on reducing EU reliance on Russian hydrocarbons on 2 March, but that has been delayed to allow the bloc

to finalise proposals. The plan will reportedly include a 40 per cent cut in fossil fuel use by 2030.

EU energy commissioner Kadri Simson said on 28 February that she hoped to synchronise European power networks with Ukraine's electricity grid so it will continue to function. She also said ministers were discussing the security of the energy supply in Europe. "We are prepared for any eventuality," she said.

European energy companies are taking matters into their own hands. UK oil giant BP said on 27 February that it would sell its 19.75 per cent share in Russian state oil company Rosneft, taking up to a \$25 billion hit. Norway's Equinor said it is also exiting joint ventures in Russia, and UK oil firm Shell followed suit.

The invasion will cause big longer-term changes in energy, says Tim Lord at the Tony Blair Institute for Global Change in the UK. "It strengthens the argument to move away from fossil fuels, for economic and geopolitical reasons [as well as environmental ones]," he says. ■

in a Mars mission," says Chris Lee, former chief scientist at the UK Space Agency. "How can we sanction that when there is a war taking place in Ukraine?"

The rover had already been delayed from 2020, partly because of the coronavirus pandemic. If it were delayed again to avoid Russian cooperation, the next window for launch would be in 2024. But Russia was also set to supply the landing system for the rover, so a new one would have to be developed from scratch. "I'd be very surprised if they could do all that within two years," says Lee.



ESA/ATG MEDIALAB

The Rosalind Franklin Mars rover is now unlikely to launch in 2022

Josef Aschbacher, ESA's director general, said on 25 February that collaborations would continue, but strains are starting to show, with reports on 28 February of ESA refusing a meeting with Rogozin.

Satellite firm OneWeb faces the most immediate challenge. The company, which the UK government owns a £370 million stake in, is in the process of deploying a megaconstellation of satellites that can beam the internet around

the world. So far, more than 400 satellites have been flown on 13 launches, all on Russian Soyuz rockets. At least five more take-offs are scheduled, including one on 4 March from Baikonur. As *New Scientist* went to press, both OneWeb and the UK government declined to comment.

"The launch campaign is in the final stages," says Anatoly Zak, editor of website RussianSpaceWeb.com. "Much of the work is done, so who knows what will happen. It looks like it is proceeding at this point." ■ Jonathan O'Callaghan

Analysis Cyberwarfare

The digital battleground Russia has a reputation for its ability to wage war online by spreading disinformation and launching cyberattacks, but this time it seems to be faltering, says **Chris Stokel-Walker**

RUSSIA has invaded Ukraine from land, air and sea, but it is also fighting on the digital front with disinformation and cyberattacks.

As Russian soldiers set foot in Ukraine on 24 February, conflicting reports spread across social media, muddying the waters and making it difficult to see how far the invasion had progressed. This was by design. Russia has long relied on its prowess in the military doctrine of *maskirovka*, or altering the perception of reality to sow confusion, says Lynette Nusbacher, former head of the UK government's Strategic Horizons Unit.

"Russia can be counted on to optimise its ability to operate in enemy [territory] and shape enemy perceptions using deception, camouflage, disinformation and perhaps deceptive artillery fires and armoured attacks in order to achieve their aims," she says.

We have already seen that in Ukraine. Alongside using what seem like staged videos that attempt to frame Ukraine as the aggressor, Russia has swarmed social media with disinformation and sent threats to Ukraine's population.

The social media *maskirovka* strategy is one that Russia has honed since 2014, when it annexed Crimea, a peninsula that was formerly part of Ukraine. "This is Russia's bread and butter," says Ed Arnold at the Royal United Services Institute (RUSI), a UK think tank.

Russia can succeed with this strategy where Western governments can't because of differing attitudes to honesty, he says. "We just can't compete

in the information war," says Arnold. "Democracies, and the way you do these things, make it very difficult."

Western efforts at combating misinformation instead tend to fall to independent open-source intelligence (OSINT) organisations, like Bellingcat, which trawl social media to puncture Russian propaganda.

1 in 5

Fortune 500 companies rely on Ukraine's IT outsourcing sector

The combination of grassroots OSINT investigators and top-down rebuttals by nation states has already tackled large volumes of Russian disinformation around the invasion of Ukraine as it is being spread online. The US and UK governments took the unusual step of revealing Russia's plans to invade Ukraine, sharing intelligence warnings of Russia's invasion prior to boots arriving on the ground. When the invasion began, OSINT investigators disseminated troop movements as they happened.

"In my assessment, Russia is decisively losing this information conflict," says Emerson T. Brooking at the Atlantic Council, a US think tank. "Its actions have received nearly universal condemnation. Its disinformation and false flags have been largely dispelled before they could take root."

Russia also seems to be faltering in its cyberassault. As the invasion began, the websites of many of Ukraine's banks and government departments were taken offline by a large distributed denial of service (DDoS) attack believed to be the work of Russia, but now the tables have turned. As *New Scientist* went to press, many Russian government websites were offline, with the hacking group Anonymous claiming to be responsible.

And while authorities in the US, UK and elsewhere were warning organisations to improve their cyber defences before the invasion began, major attacks have yet to materialise.

Part of the risk to these nations isn't from a direct Russian attack on IT infrastructure outside

Ukraine – though that could happen – but instead an attack on Ukrainian IT affecting Western businesses. One in five Fortune 500 companies rely on Ukraine's IT outsourcing sector, according to Ukraine's Ministry of Foreign Affairs.

"We've seen in the past that Russia has the intent and capability to cause major disruption through cyberoperations," says Jamie MacColl, also at RUSI.

Ready to act

Both the US and UK seem ready to fight back. According to *NBC*, US president Joe Biden has been presented with a "menu of options" for cyberattacks against Russia, including disrupting internet connectivity or shutting down the nation's power grid.

Meanwhile, UK defence minister Ben Wallace told parliament on 21 February that a long-planned offensive cyberattack agency, the National Cyber Force, had "already been established" and was growing in size, adding that "the best part of defence is offence".

This is no surprise, says Nusbacher. "People at a senior level in Western governments have for a decade or more been calling for calibrated cyberattack options to respond to both kinetic and cyber incoming attacks."

"For the moment, it seems that most such incursions are considered digital espionage and sabotage, more so than full-out conflict," says Agnes Venema at the University of Malta.

Any attacks by the UK wouldn't be against Russian civilian infrastructure, says MacColl. "It will be about degrading [Russia's] ability to conduct cyberattacks against us." ■

The Ukrainian flag drawn with stylised computer code



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Climate change

It will be increasingly difficult to adapt to a warming world, but it's not too late

Adam Vaughan

CLIMATE change is already causing widespread, pervasive and sometimes irreversible harm to people and ecosystems globally, according to a landmark report warning it has become increasingly clear there are limits to how much humanity can adapt to rising temperatures.

The latest report by the Intergovernmental Panel on Climate Change (IPCC) has found that up to 3.6 billion people live in areas highly vulnerable to climate change, largely from extreme heat, heavy rainfall, drought and weather setting the stage for fires. During a press conference, UN secretary-general António Guterres called it “an atlas of human suffering”.

Since the panel's last assessment eight years ago, it has increasingly been possible to pin the impacts of extreme weather events on human-made climate change. A clear message from the report is that holding warming to the Paris Agreement's 1.5°C goal will limit its impacts and make adaptation more feasible. Despite the pledges nearly 200 countries made in the Glasgow Climate Pact at the COP26 summit last November, the world is still on track for more than 2°C of warming.

The report finds that climate change is already affecting people's physical health and explicitly mentions mental health too, for the first time in an IPCC report. Helen Adams at King's College London, an IPCC lead author, says the main mental toll is from extreme weather impacts, such as dealing with flooded homes, but also through “eco-anxiety”.

Climate change's burdens are falling unequally, with the world's most vulnerable people mostly in low-income nations, says the report. Deaths from floods, droughts and storms in such



DON WILSON/ODHAMBOSIPA IMAGES/LIGHTROCKET VIA GETTY IMAGES

There was a water shortage in Nairobi, Kenya, in January

places were found to be 15 times higher than the least vulnerable areas, mostly high-income nations, between 2010 and 2020. Overall, the economic impact of a rapidly warming world has been adverse, according to the report. But there have been economic positives regionally, including for farming and tourism, and in lower energy demand.

The IPCC highlights the impact on cities, now home to more than half the global population. Urban areas are increasingly being hit by heat, floods and storms affecting energy and transport, and aggravating air pollution.

The 2030s and 2040s will bring an unavoidable rise in hazards for people worldwide because there is already 1.5°C of warming baked in by our past greenhouse gas emissions. By mid-century, around a billion people will be at risk of coastal impacts such as flooding, including those in small island states, some of which face

an “existential threat” later this century. If the world warms by 2°C, that will endanger food security, leading to increased malnutrition in some regions.

It isn't only humans bearing the brunt: climate change is thought to be responsible for at least two species' extinctions. If global average temperatures rise by 1.5°C, up to 14 per cent of species on land will be likely to face a very high risk of extinction in future. At 3°C, the figure is up to 29 per cent.

However, Adams cautions against being fatalistic in the face of dire projections, because they hinge on how much societies cut their emissions and how much they adapt. “Yes, things are bad. But actually, the future depends on us, not the climate,” she says. The report finds that holding warming to 1.5°C “substantially” cuts the losses and damages from climate change, but “cannot eliminate them all”.

Attempts to adapt to a warming world, such as building flood defences and planting different varieties of crops, have made progress since the last assessment

in 2014. But they fall far short of what is needed, they are uneven globally and there is growing evidence that adaptation can have negative side effects, such as sea defences causing knock-on erosion along coasts. “Most observed adaptation is fragmented, small in scale, incremental”, says the report.

The report was published on the fifth day of the Russian invasion of Ukraine, and one of its authors says the war risks derailing focus and action on climate change. “If we're going back into a world of a cold war, thinking about climate change is something which we then don't do with the urgency with which we need,” says Daniela Schmidt at the University of Bristol, UK.

On 27 February, during final approval of the report, which governments sign off line by line, the head of the Russian delegation reportedly told colleagues that “this [war] is not the wish of all the Russian people and the Russian people were not asked”. The Ukrainian delegation asked

“Any further delay in action will miss a brief window of opportunity to secure a liveable future for all”

colleagues to continue and expressed how upset they were the war “will detract from the importance” of the report, *Climate Change 2022: Impacts, adaptation and vulnerability*.

The assessment, part of the sixth round of reports by the IPCC since the first in 1990, closes with an urgent message: “Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all.” ■

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Action Tutoring**



Tackling education inequality head-on

WHAT'S THE ISSUE?

Education in this country isn't fair. Young people from disadvantaged backgrounds don't do as well in school as their peers. This isn't because they are any less able but because they don't have access to the same opportunities which enable progression. This can significantly limit their future paths.

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Justina, volunteer maths tutor and consultant paediatrician

It provides a safe space for pupils with low confidence to speak up and overcome the obstacles they're facing. The Education Endowment Foundation has calculated that an intense programme of one-to-one tuition could add as much as five months' progress to a young person's schooling.

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The world's first bitcoin republic El Salvador's adoption of the cryptocurrency has attracted enthusiastic tourists, concern from financial institutions and scorn from locals, reports **Luke Taylor**



"FIFTY cents for a pupusa," says Carolina Reyes, a food vendor in El Palmarcito, El Salvador, as she throws the cornmeal pancakes on the grill. "Bitcoin or cash?"

A growing number of Reyes's customers are transferring cryptocurrency into her digital wallet rather than handing over bills. "Americans, French, Canadians, they're all paying in bitcoin for my pupusas," she says.

Tourists have long been drawn to El Salvador for its surf, but now they are coming to see the world's most popular cryptocurrency in action. In September 2021, the country's president, Nayib Bukele, declared bitcoin legal tender in El Salvador, making it the first country where businesses are required to accept the digital currency. Bukele argues that using bitcoin will bring Salvadorans who



An advertisement for bitcoin on a roadside in El Salvador

that the move was yet to benefit them. The country plans to install 1500 Chivo ATMs, some of which were torched in protests in September 2021 and are mocked for being of use only to stray dogs that lie in their shade.

Many Salvadorans refuse to use bitcoin because its value swings wildly, or they don't trust it. Oscar Salguero, a software engineer from San Salvador, says bitcoin's decentralised, transparent, peer-to-peer transactions could be used to usher in a new financial and political order by cutting out the tyrannical governments that have historically run the region, but that isn't happening. "Sadly, in El Salvador," he says, "it's just become another tool for corruption."

There are concerns elsewhere too. US senators introduced a bill to examine whether bitcoin could be used in El Salvador to traffic drugs or launder money.

The World Bank has refused to support Bukele's bitcoin experiment, and the International Monetary Fund, which is negotiating a \$1.3 billion loan with El Salvador, is urging Bukele to turn back before it is too late.

El Salvador has spent \$180 million on the Chivo Wallet and bitcoin ATMs. The value of the \$85.5 million in bitcoin that the country purchased with taxpayer money is estimated to have dropped to \$76.1 million. Ratings agencies have downgraded El Salvador's bonds to below investment grade.

For many Salvadorans – half of whom don't have internet access, and one in five of whom live on less than \$5 a day – Bukele's plans seem as intangible as bitcoin itself. ■

66%

Salvadorans opposed to making bitcoin national currency

have never held a bank account into the financial system, save hundreds of millions of dollars lost in fees when money is sent home from family members abroad, and make El Salvador the tech hub of Latin America.

Tourism has spiked 30 per cent since bitcoin became legal tender. El Salvador is considering offering citizenship to people who invest more than \$100,000 in bitcoin to accommodate those who want to live in a crypto economy.

It would be one of Bukele's less outlandish plans. His government has teamed up with a company called Astro Babies to launch a virtual casino where guests can gamble bitcoin and trade NFTs (non-fungible tokens), with a physical branch in El Salvador. In November 2021, he presented

his vision for Bitcoin City, a tax-free metropolis to be built in the shape of a bitcoin logo at the base of Conchagua volcano.

Bukele said that Conchagua's geothermal energy will power the city and computers mining bitcoin. A billion dollars worth of "volcano bonds" are to be issued in March, half of which will be used to fund the project, and the other half to buy bitcoin.

Foreign entrepreneurs seeking to take part in El Salvador's crypto boom are already relocating to the surf village of El Zonte, now better

A store owner in surfing hotspot El Zonte, now known as Bitcoin Beach



Omega-3 supplements could cut the number of preterm births

Alice Klein

GIVING omega-3 supplements to pregnant women with low levels of this fatty acid could prevent about 14 per cent of early preterm births, according to data from an Australian trial. The finding has inspired a world-first screening and treatment programme for omega-3 deficiencies in pregnant women in South Australia.

Omega-3 fatty acids are found in fish and are known to protect heart and brain health, and there is evidence that they are also important in pregnancy. For example, observational studies have shown that eating fish regularly during pregnancy seems to lower the risk of premature birth.

A few years ago, Maria Makrides at the South Australian Health and Medical Research Institute and her colleagues ran a trial in which they randomly assigned 5500 pregnant women to have either 1 gram of



MARK WIENER/LAMY

Omega-3 fish oil can be taken as daily supplements

omega-3 per day in the form of fish oil capsules or a placebo, starting any time before 20 weeks of gestation (*NEJM*, doi.org/ghbsx8).

They found that in women who started out with low levels of omega-3 in their blood, supplements of omega-3 fatty acids reduced the risk of birth happening before 34 weeks of gestation by 77 per cent. The placebo had no effect on the risk of such early premature birth.

But for women who already had high omega-3 levels, taking the omega-3 supplements actually increased their risk of these

preterm births. This suggests that the supplements should only be recommended to pregnant women with low omega-3 levels, although multivitamins containing small omega-3 doses are fine for women who already have high levels, says Makrides.

On the back of these results, Makrides has helped launch a screening programme in the state of South Australia that offers free blood tests to all pregnant women to identify and treat those who are low in omega-3. About 3000 women have been screened since May 2021 and so far 17 per cent have been found to have low omega-3 levels.

Based on the earlier clinical trial results, Makrides and her team estimate that recommending omega-3 supplements to these women with low omega-3 levels could prevent 1 in 7 early preterm births across South Australia.

Currently, there are few effective ways to prevent premature births, which increase the risk of death or disability in babies, says Makrides, who will present the first results of the screening programme at the annual scientific meeting of the Royal College of Pathologists of Australasia on 6 March.

“Finding ways to prevent premature birth is one of the highest priorities in maternal and child health”

“Finding ways to prevent premature birth is one of the highest priorities in maternal and child health,” she says.

It isn't clear why omega-3 fatty acids protect against preterm birth, but there is some evidence that it influences pre-labour changes to the cervix and contractions of the uterus, says Makrides. ■

Animal behaviour

Slug faeces help mushrooms start new colonies

SLUGS may be important dispersal vehicles for fungal spores, spread through their faeces. The molluscs deliver spores from a wide range of forest fungi to microhabitats perfect for new fungal colonies.

Nobuko Tuno and Keiko Kitabayashi at Kanazawa University in Japan collected mantleslugs (*Meghimatium fruhstorferi*) in a forest, briefly keeping them captive so they could collect droppings. They used microscopes to detect any spores in the faeces and DNA analysis to identify the fungal species present.

Nearly three-quarters of the slugs had fungal spores in their faeces.



NOBUKO TUNO

The researchers detected the DNA of dozens of different fungal species in the droppings of eight slugs. Most of the fungi were wood-rotting varieties, but there were also pathogenic species and ones that form beneficial symbiotic relationships with trees (*Ecology and Evolution*, doi.org/hh43).

Many spores didn't experience any decline in their germination rate after being excreted. In fact, some appeared to start germinating while in the guts of the slugs. Tuno thinks moisture in the digestive tract and in fresh droppings may speed the process.

Researchers also tracked the

Young mantleslugs feeding on oyster mushrooms

movement of five slugs through their forest habitat at night for several hours, marking the position of each every 30 minutes. They found that the molluscs tend to move through leaf litter and wood debris well-suited to new fungal colonies, something made more likely by the quantity of spores in slug droppings.

“The overwhelming number of spores being dispersed in a germinated state” would be an advantage over competing decomposer species, says Tuno. ■
Jake Buehler

Meet the slug hunter with a new way to keep molluscs at bay, page 48

Palaeontology

Was *T. rex* actually three separate species?

Colin Barras



EQROYALAMY

THE “tyrant lizard king” – *Tyrannosaurus rex* – might have belonged to a dynasty. A research team has proposed splitting the famous species into three, with *Tyrannosaurus imperator* (tyrant lizard emperor) and *Tyrannosaurus regina* (tyrant lizard queen) taking their places next to *T. rex*. But the proposal is already proving unpopular with other palaeontologists.

T. rex was an apex predator that lived in North America between about 68 and 66 million years ago. The first *T. rex* fossils were discovered more than a century ago, but for decades very few skeletons were known. More have come to light since the 1990s, says Scott Persons at the College of Charleston, South Carolina, which means it is now possible to assess whether the animals fall into a single species.

To explore this question, Persons and his colleagues looked at bones from 38 *T. rex* fossils, focusing in particular on two features: the number of front teeth in the lower jaw and the stoutness of the thigh bones.

They discovered variation in both features, which they think justifies splitting the dinosaurs into three distinct species. The oldest animals – which had four distinctly small incisors at the front of the lower jaw and the stout thighs of a heavily built dinosaur – are placed in the new species *T. imperator*.

“There are anatomical changes that seem to change with time. That is pretty amazing in itself”

The researchers believe this then evolved into two younger species, both of which had just two small incisors at the front of the lower jaw. One of these younger species had slender thigh bones and was lightly built – it has been named *T. regina*. The other had stout thighs and was heavily built; this species retains the name *T. rex* (*Evolutionary Biology*, doi.org/hjc4).

“There will be those who say you’re naming them just because it’s intrinsically fun and cool to name a new *Tyrannosaurus*,” says Persons, but he argues that the decision

Sue, the *Tyrannosaurus* skeleton at the Field Museum in Chicago

is justified. He says modern ecosystems show us that apex predators evolve and diversify into distinct species – lions and leopards, for example – and it is very likely that *Tyrannosaurus* did so too.

The conclusions have implications for some of the most famous *Tyrannosaurus* fossils, he adds: Sue, a skeleton at the Field Museum in Chicago, is actually *T. imperator*, while Stan – which was sold to a private buyer for \$32 million in 2020 – should be reclassified as *T. regina*.

Philip Currie at the University of Alberta, Canada, expects the proposal to stimulate debate. “I think the authors have made a case that there are anatomical changes in the genus that seem to [change] with time,” he says. “That is pretty amazing in itself.”

But others will take more persuading. “I understand the temptation to divide *T. rex* into different species, because there is some variation in the fossil bones that we have,” says Stephen Brusatte at the University of Edinburgh, UK. “But ultimately, to me, this variation is very minor. Until I see much stronger evidence, these are all still *T. rex* to me.”

Thomas Carr at Carthage College in Wisconsin also thinks the evidence in the new paper is weak. His own in-depth analysis of *T. rex* looked to uncover patterns in the data, but he found nothing that made him think there was more than a single species. “I just think they’re seeing what they want to see,” he says. ■

Animal behaviour

Dogs show grief when other dogs they live with die

Clare Wilson

PET owners may have long suspected it, but now a study has found that nearly 90 per cent of dogs that experienced the death of a “companion” canine in the same household showed behaviours that seem to indicate suffering in the months after. This included being less playful, eating less, being more fearful and seeking more attention.

While grief-like behaviour has been seen in wild animals such as elephants, orcas and chimpanzees, it hasn’t been studied in pet dogs, despite many reports of the phenomenon from their owners.

Federica Pirrone at the University of Milan, Italy, and her colleagues surveyed 426 people who had at least two dogs, one of which had died, and asked about changes to the behaviour of the surviving pets.

These dogs were more likely to “mourn” a former companion if the two had had a friendly relationship, especially if they used to share food (*Scientific Reports*, doi.org/hh4t). The reactions were unaffected by how long the two dogs had known each other, but nearly all had lived together for more than a year.

Dogs were also more likely to be badly affected if their owner also felt more grief. “Dogs have become extremely sensitive to human communicative gestures and facial expressions,” says Pirrone. “A caregiver and a dog develop an emotional connection.” ■

Dogs that lose a canine companion eat and play less, and seek more attention



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Evolution

Largest ever family tree of humanity reveals history of our species

Michael Marshall

THE biggest family tree of humanity to date has been built using genetic data from thousands of modern and prehistoric people. The tree gives a view of 2 million years of prehistory and evolution.

“Humans are all ultimately related to each other,” says Gil McVean at the University of Oxford. “What I’ve long wanted to do is to be able to represent the totality of what we can learn about human history through this genealogy.”

Geneticists have been reading people’s entire genomes for the past two decades. McVean and his colleagues compiled 3609 of these, almost all of which belonged to our species, *Homo sapiens*, except for three Neanderthals and one from the Denisovan group, which may be a subspecies of *H. sapiens* or a separate species.

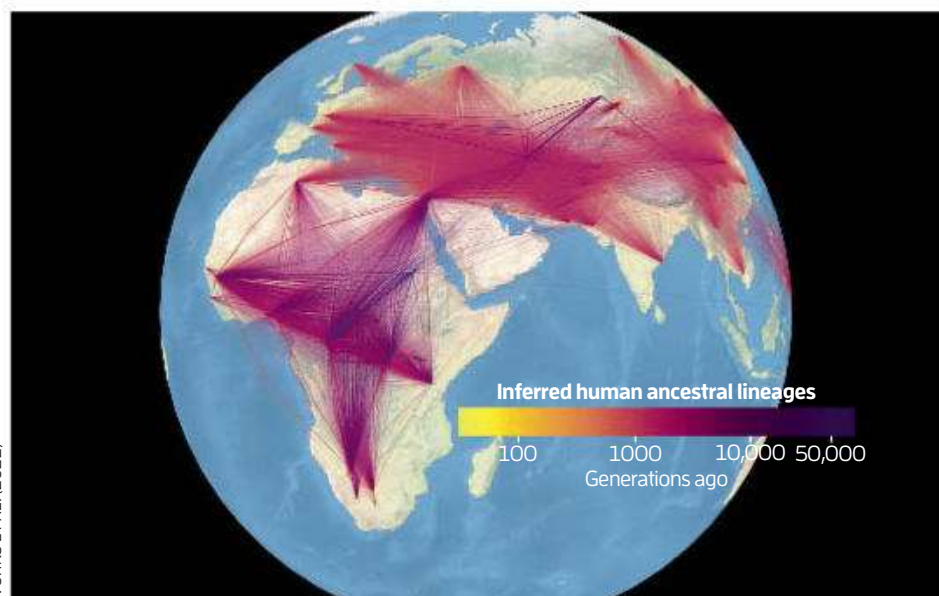
Putting them together into a tree was challenging. “The different data sets have been produced over time, using different technologies, analysed in different ways,” says McVean.

The team focused on bits of

DNA that vary from person to person. They identified 6,412,717 variants and tried to figure out when and where each arose. To do this, they also looked at an extra 3589 samples of ancient DNA that weren’t good enough to include in the tree, but did shed light on when the variants emerged.

Variants that emerged before 72,000 years ago were most

Family ties between genomes visualised as lines on a map



common in north-east Africa, and the oldest 100 variants were also from there, specifically in what is now Sudan. Those oldest variants are about 2 million years old, so long predate our species, which emerged around 300,000 years ago. Instead, they date to the earliest members of our genus, *Homo* (*Science*, doi.org/hh3h).

The simplistic interpretation of this is that humanity first evolved in this region, but later migrations are likely to have interfered with the data. “I would definitely not

take the naive and immediate answer,” says Jennifer Raff at the University of Kansas.

The earliest *H. sapiens* fossils are from the north and east of Africa, but few have been discovered, so we don’t know our species’ early range with any certainty.

Many anthropologists now think multiple populations were spread across Africa, which were sometimes apart and sometimes interbred. If that is correct, humanity doesn’t have a central origin point.

“Our findings are certainly perfectly compatible with that,” says McVean. “There’s a lot of very deep lineages within Africa, which are suggestive of that notion of there being multiple source populations, very deeply diverged, representing really ancient splits.”

The tree also offers clues that people reached Papua New Guinea and the Americas tens of thousands of years earlier than the archaeological record implies, hinting at migrations that have yet to be discovered. But both these ideas would need to be confirmed by archaeological finds. ■

Energy

Price tag rises for UK’s planned nuclear waste facility

THE cost of a proposed underground storage facility to safely house the UK’s nuclear waste for millennia has risen to as much as £53 billion, more than double the previous estimate, according to a new government report.

The UK currently stores its 133,000 cubic metres of radioactive waste above ground, and the quantity is projected to swell to more than 4 million cubic

metres in future. In 2018, the government rebooted its search for a community in England willing to host an underground store, known as a geological disposal facility, after a previous effort was rejected by local authorities in 2013.

Four years ago, the project was estimated to cost between £12 billion and £20 billion to build and operate for 150 years. However, in an annual report published on 18 February, UK government agency Nuclear Waste Services (NWS) revised the figure up to between £20 billion and £53 billion. The cost will be shouldered by taxpayers

and nuclear power operators, with each paying roughly half.

John Corderoy at NWS says the huge increase is due to a broader scope of costs and being more realistic. The wide range of the estimate is due to the potentially large differences in where the facility could be situated.

But the biggest increase comes from expecting more waste, including legacy radioactive

4 million

Projected quantity of the UK’s radioactive waste, in cubic metres

material from a fleet of new nuclear plants, as well as uranium and plutonium that were deemed an asset in the past, but are now considered waste. “We’re counting more things,” says Corderoy.

Roy Payne at GDFWatch, a UK non-profit that tracks this issue, says: “The initially eye-popping increase in the upper projected costs can probably be explained by the change of management and culture at NWS that takes a more informed and realistic view of the project, the external market and geopolitical factors.” ■
Adam Vaughan

Environment

Antibiotics on crops may harm the ability of bees to find food

Gary Hartley

EXPOSURE to streptomycin, an antibiotic used to treat crop diseases in the US, weakens the foraging capabilities of the common eastern bumblebee, which may have negative implications for plant pollination.

The use of antibiotics for spraying crops has increased exponentially in recent years, with streptomycin predominantly used in the US to control the bacterial disease fire blight in apple and pear orchards.

To assess the impact of contact with the drug on a key pollinator, Laura Avila at Emory University in Atlanta, Georgia, and her colleagues fed a group of eastern bumblebees (*Bombus impatiens*) a diet of sucrose mixed with streptomycin at a concentration of 200 parts per million – representative of strengths used to spray crops. A control group received sucrose alone. After two days on these diets, the bees were given a series of tests.

Bees exposed to streptomycin took longer to be trained to associate sucrose and water with different coloured strips of card soaked in the liquids. Also, in a 2-hour foraging test in which the bees were tracked by radio tags, they visited fewer sucrose-filled artificial flowers than bees in the control group (*Proceedings of the Royal Society B*, doi.org/hhw6).

"We are conducting follow-up work to see if these behavioural effects are driven by changes in the bee gut microbiome," says Avila.

"Laboratory studies from other research groups have shown that antibiotics can – unsurprisingly – disrupt bee gut microbiomes," she says, "and work in other insects has shown microbiome changes can impact insect behaviour."

The researchers are also beginning to assess the levels of exposure to the drugs faced by bees in the real world when they are sprayed on crops. ■

Analysis Space junk

Whose rocket is about to hit the moon? A chunk of space junk will hit the lunar surface this week and it is troubling that no one is admitting responsibility, finds Jonathan O'Callaghan



CHINA has denied it is the owner of a rocket that is about to hit the moon – but experts believe it is.

The confusion has highlighted our inadequacies in tracking space junk, particularly at remote distances from Earth. The impending collision also has implications for the idea of returning humans to the moon this decade.

In January, astronomers announced that a human-made object was set to hit the far side of the moon on 4 March.

Initially identified as the upper stage of a SpaceX Falcon 9 rocket that took off in 2015, later analysis showed it was more likely to be part of a Chinese rocket launched to the moon in 2014, a practice run for returning lunar samples to Earth in 2020.

China disagrees. In a press conference on 21 February, Wang Wenbin, a spokesperson for China's foreign ministry, said the country's data showed the rocket had previously "entered into Earth's atmosphere and completely burned up", letting China off the hook.

But Bill Gray, an independent astronomer in the US, believes China has mistaken debris from

a later mission in 2020 for debris from the practice mission in 2014.

"We have increasingly solid evidence," says Gray, including analysis of paint on the object headed towards the moon that links it to China. "I don't think anybody at this point is seriously considering it being anything else."

The issue has highlighted that tracking space debris, especially at large distances from Earth, is extremely difficult.

Experts use launch data to estimate where objects like these will go, but making accurate

9

Lunar missions are planned for this year alone

predictions without an easy way to follow them in space – particularly if they fly past the moon – is difficult.

"It's an intrinsically hard problem," says Jonathan McDowell at the Harvard-Smithsonian Center for Astrophysics. "Sometimes, we make mistakes."

While debris is tracked in low Earth orbit by organisations like the US military, there is no official

On 4 March, a mystery rocket will crash into the far side of the moon

body tasked with tracking debris further out to the moon's orbit. Instead, people like Gray and McDowell do the job in their spare time. "We are the only people keeping track of these things," says Gray.

That doesn't pose many problems for now; only a few dozen human-made objects are in distant orbits around the moon.

But lunar activity is set to increase in the coming years, with multiple uncrewed missions set to launch before NASA hopes to return humans there later this decade.

"We've got nine missions going to the moon this year alone," says Alice Gorman at Flinders University in Adelaide, Australia. "Fast forward 10 years and somebody might have an industrial installation at the moon's south pole. If there's an uncontrolled re-entry of some random thing, those risks are very different."

Holger Krag, space safety manager for the European Space Agency, says one solution might be to designate regions of the moon where objects can be disposed, similar to how a portion of the South Pacific Ocean is used to crash dead spacecraft and even entire space stations. "We need to decide on these things pretty soon," says Krag. Spent rocket boosters could also be equipped with tracking beacons "so you always know where they are", says Gorman.

For now, our knowledge of these objects relies on the spare time of people like Gray. "I don't think this really should be something that is left to one person," he says. "I may wind up getting a different job." ■

Extra competition has made UK baby boomers the unhappiest generation

Alice Klein

BABY boomers are the least happy generation in the UK despite being one of the most well-off, new research shows. The main reason for this appears to be their sheer number, which has led to competition for jobs, houses, partners and everything else.

Yiwan Ye and Xiaoling Shu at the University of California, Davis, analysed data from a social survey

5 or below on a scale running from 0 to 10.

The happiest generations were the youngest and oldest. Only 10 per cent of Gen Zers, born between 1997 and 2012, and just 12 per cent of the “Greatest” generation, born between 1900 and 1927, said they were unhappy (*Journal of Happiness Studies*, doi.org/hh36).

This might suggest that baby boomers may be less happy because they are at a tricky age, possibly struggling with the move into retirement or the triple demands of children, grandchildren and elderly parents. But Ye says this isn’t the case, as they were also unhappiest when the survey began in 2002, when some were only in their late 30s. Moreover, the generations above were happier when they were the age that boomers are now.

So what is going on? Ye and Shu’s analysis found that cohort size was the biggest predictor of happiness, accounting for 48 per cent of the variation between generations. The large size of the boomer generation seems to

have made it the most miserable.

“Baby boomers competed with more siblings when they were growing up, more students at school and more people when they entered the job and housing market,” says Ye. Snagging the partner they wanted might also have been harder due to greater competition, he says. As a result, boomers may have experienced more psychological stress from

falling short of aspirations and comparing themselves with more successful peers, he says.

Ye and Shu also found that boomers had the highest separation and divorce rates of any generation and were least likely to socialise on a daily basis, which probably also contributed to their relative gloom.

One of the most interesting findings of the study is that happiness doesn’t appear to be tied to the wealth of the age cohort, says Matthew Wright at Appalachian State University in North Carolina. The boomers ranked second in income, just behind Gen Xers, who were born between 1965 and 1980. “The saying ‘money doesn’t buy you happiness’ is actually true,” he says.

Ye and Shu are now analysing similar survey data from the US and have found that US boomers are also the least happy generation, again seemingly because of their large cohort size. Next, they plan to see whether these cohort effects are lessened in countries with strong social support systems, like those in Scandinavia, says Ye. ■

Those born between 1946 and 1964 are the most miserable



SHUTTERSTOCK/PHOTOGRAPHEE.EU

“Baby boomers competed with more people when they entered the job and housing market”

that is conducted every two years in the UK to gauge people’s happiness and examine other social trends. The data spanned 2002 to 2018 and involved more than 19,000 people across the UK.

They found that baby boomers – people born between 1946 and 1964 – were the unhappiest generation over the survey period. When asked, “taking all things together, how happy would you say you are?”, 17 per cent of boomers reported being unhappy, meaning they selected a score of

Materials

Art of paper cutting inspires light yet strong material

A METAMATERIAL inspired by kirigami, the Japanese art of paper cutting, can support nearly 3000 times its own weight.

Metamaterials have structures not found in nature, which can give them unusual characteristics such as high strength under load.

Zhang Hongying at the National University of Singapore and Jamie Paik at the Swiss Federal Institute of Technology in Lausanne designed

an interlocking kirigami pattern for paper that forms a thin shell of alternating squares. The shell can be bent into three-dimensional shapes using a computer model the pair created.

“The repeating chequerboard pattern allows us to distribute the load overall,” says Paik. “The distributed load you get for the very small thickness of this quasi-2D [surface] is remarkable.”

Although a 5-centimetre cube made from the kirigami material weighs only around 12 grams, Zhang and Paik found it could support a force of 346 newtons –



HONGYING ZHANG AND JAMIE PAIK

Strong shapes made from a kirigami-inspired material

equivalent to a 35 kilogram weight, or about 2900 times heavier than the cube itself (*Advanced Functional Materials*, doi.org/hh4d).

The pair’s model can calculate how to bend the 2D structure into various complex configurations. They hope it will be used by

researchers in other fields where strong, lightweight structures are needed, such as aerospace engineering or medicine.

“The advantage of this type of metamaterial is that it can adapt to different shapes or adapt to different external surfaces or volumes,” says Fabrizio Scarpa at the University of Bristol, UK.

The kirigami is laborious to produce because the shell structures have to be folded by hand. For commercial uses, the process would probably have to be scaled up and automated, says Paik. ■

Alex Wilkins



JUNG GETTY/GETTY IMAGES

Diet

Edible wild plants could help address global malnutrition

WILD plants are an overlooked source of vitamins and minerals that could help fight malnutrition.

A lack of B vitamins in food can be a cause of ill health, for example in parts of Africa. Poor variety in diet is a factor. While thousands of plants are edible, people around the world get most of their plant-based calories from just three staple crops: rice (pictured), maize and wheat.

Now, more than 1000 wild edible plants have been identified that contain thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5) and folate (B9).

Aoife Cantwell-Jones at Imperial College London and her colleagues predicted the levels of these five B vitamins in about 6400 edible plants that grow in various countries, based on how closely each species is genetically related

to other plants that have already been nutritionally analysed.

They checked their method worked using nearly 300 plants where the vitamin B content is known. Using this technique, they identified 1044 species as good sources of this group of vitamins, although 6 per cent of them are classed as threatened in the wild and a quarter of them haven't been preserved in seed banks (*Nature Plants*, doi.org/hh24).

Getting people to eat these plants is another matter. "Education is really important in combating malnutrition, knowing that you need to eat a diverse diet and not just rely on staple crops," says Cantwell-Jones. "Maybe people know that these plants exist in some local communities, but not at the national level." **Clare Wilson**

Astrophysics

Skewed black hole is a real space oddity

A BLACK hole that is spinning on a severe tilt to the plane of its orbit suggests we need to rethink our understanding of how they work.

Most masses in space, including black holes, rotate in the same plane that they revolve around nearby objects, typically because such closely located objects formed from the same cloud of dust or gas. If an object is tilted relative to its orbit, it can imply something unusual happened during its formation or history.

Now, Juri Poutanen at the University of Turku, Finland, and his colleagues have realised a black hole about 10,000 light years from Earth is tilted by at least 40 degrees from the plane in which it is revolving with its binary partner, a star with about half the mass of the sun.

The black hole, named MAXI J1820+070, gives off a weak signal

of polarised light, which the researchers used to establish its orbital plane. They then used the orientation of the black hole's radiation jets to calculate a lower bound on the black hole's tilt (*Science*, doi.org/hh3q).

This tilt could explain the observation of strange signals – called quasi-periodic oscillations (QPOs) – that come from black holes. QPOs are peaks in intensity at certain frequencies. A popular model suggests these are a result of misaligned spins and orbits, as is the case for MAXI J1820+070, which also produces QPOs.

While it isn't clear exactly how this black hole acquired such a tilt, it probably came from instabilities when its parent supernova collapsed, says Poutanen.

Astronomers often assume that the orbital plane and spin axis are aligned when calculating the mass and spin of black holes. But if this assumption isn't reliable, then those calculations could be incorrect. **Alex Wilkins**

Zoology

Gorilla faces warped by lots of inbreeding

THE degree of distortion in facial features is on the rise in certain endangered gorilla species, possibly due to inbreeding.

Facial asymmetry in primates – including humans – is marked by a sort of spiralling of the facial features around a central point just above the jaw. Once thought to be a consequence of early life challenges, a study in gorillas suggests that the phenomenon

may be the result of inbreeding, says Kate McGrath at the State University of New York.

To investigate, she and her team analysed skulls of 40 mountain gorillas (*Gorilla beringei beringei*), comparing them with those of 40 eastern lowland gorillas (*Gorilla beringei graueri*) and 34 western lowland gorillas (*Gorilla gorilla gorilla*). All were adults, made up of both males and females that had died between 1880 and 2008.

They found that the mountain gorillas had nearly twice as much facial asymmetry compared with eastern lowland gorillas, and nearly three times as much as western lowland gorillas.

The results line up with the level of inbreeding in each population, says McGrath. Western lowland gorillas have been the least inbred of the three subspecies, while the mountain gorillas are exceptionally inbred (*Proceedings of the Royal Society B*, doi.org/hh3k). **Christa Lesté-Lasserre**



MCCRATH ET AL



Really brief



BIOSPOTO/ALAMY

Guppy fish fooled by optical illusions

Optical illusions work on some fish, but not in the same way they do on us. From guppies' behaviour, it seems that an optical illusion that makes a hole seem larger than it really is to humans, actually makes the hole seem smaller than it is in reality to these fish (*Biology Letters*, doi.org/hhxd).

Obesity rates lower in walkable towns

Treating diabetes and obesity costs healthcare systems billions each year. But a review of 170 earlier studies concludes that rates of both of these conditions can be reduced by transforming towns and cities into places where it is safe and convenient to walk or cycle (*Endocrine Reviews*, doi.org/hhxg).

Tough tests needed for new gas projects

The UK Climate Change Committee has called for a tightening of proposed UK government tests to decide whether new oil and gas projects are compatible with climate targets. The independent advisory group also said it wanted to "bust the myth" that more drilling was the answer to current high energy prices.

Pollution

Cleaning an office makes dirty air

SCENTED surface-cleaning products can expose you to a similar amount of pollutant particles as a busy urban road used by 28,000 vehicles a day. The findings suggest that professional cleaners may be especially at risk from indoor pollutants.

Such products often contain chemicals called monoterpenes that smell like citrus or pine. Monoterpenes easily evaporate into the air where they react with

substances such as ozone to produce pollutant particles called secondary organic aerosols (SOAs).

SOAs – which are also generated by vehicle fumes – can irritate your airways and introduce chemicals into the bloodstream.

Colleen Rosales, while at Indiana University, and her colleagues cleaned the floor of an office room for 15 minutes using a mop soaked in a scented commercial cleaning product, repeating this a few hours later. They then tracked the levels of small SOAs – with a diameter of 10 nanometres or less – in the air during and after cleaning.

By modelling how particles enter the respiratory system, they calculated that being in a room during 1.5 hours of mopping would expose the lungs to similar pollutant particle levels as 1.5 to 6 hours spent by a busy road. This was based on previously published pollution data from a road used by thousands of vehicles a day and lined by multistorey buildings (*Science Advances*, doi.org/hh9f).

However, more research is needed to establish the health effects of these indoor pollutants, the team says. **Carissa Wong**

Health



JUSTIN PAGET/GETTY IMAGES

Dogs trump cats in helping people stay fit as they age

PEOPLE who own a dog have a much lower risk of disability in older age, but cat owners don't. Unsurprisingly, the benefit is lost if you don't walk your dog – or take part in another form of exercise – more than once a week.

Yu Taniguchi at the National Institute for Environmental Studies in Tsukuba, Japan, and his colleagues asked around 11,000 people aged 65 to 84 years old if they currently or previously owned a cat or dog. The researchers then tracked the onset of cognitive and physical disability in the participants for 3.5 years between 2016 to 2020.

They found that current dog

owners who exercised more than once a week were around half as likely to develop a disability compared with people who had never owned a dog, even when controlling for age, sex, income and health factors such as smoking, diet and cardiovascular disease.

The team also found that people who owned dogs in the past had around a 10 per cent lower risk of disability compared with those who had never owned a dog.

Meanwhile, current and former cat owners were just as likely as people who had never owned a cat to develop a disability (*PLoS One*, doi.org/hh29). **Carissa Wong**

Sleep

Hyper neurons may lead to poor slumber

IT MAY get harder to sleep as we age because neurons that promote wakefulness become overactive, a study in mice suggests.

Luis de Lecea at Stanford University in California and his team analysed a set of neurons in the hypothalamus of mouse brains that produce a protein called hypocretin. These neurons have been implicated in wakefulness in both humans and mice.

When comparing this set of neurons in young and old mice, they found that the hypocretin neurons in the older mice fired more easily – which is known as being hyperexcitable – and were therefore overactive. When they treated older mice with a drug that reduced this hyperexcitability, their sleep quality improved (*Science*, doi.org/hh34).

De Lecea says he has no idea what may be causing this hyperexcitability in the first place, but since hypocretin neurons are also present in humans and have the same function, this gives us a potential drug target for people.

Beyond worsening quality of life, poor sleep has also been linked to the development of neurological disorders such as Alzheimer's disease.

Jason Arunn Murugesu

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The columnist

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Jacob Aron fights zombies with the power of parkour **p36**

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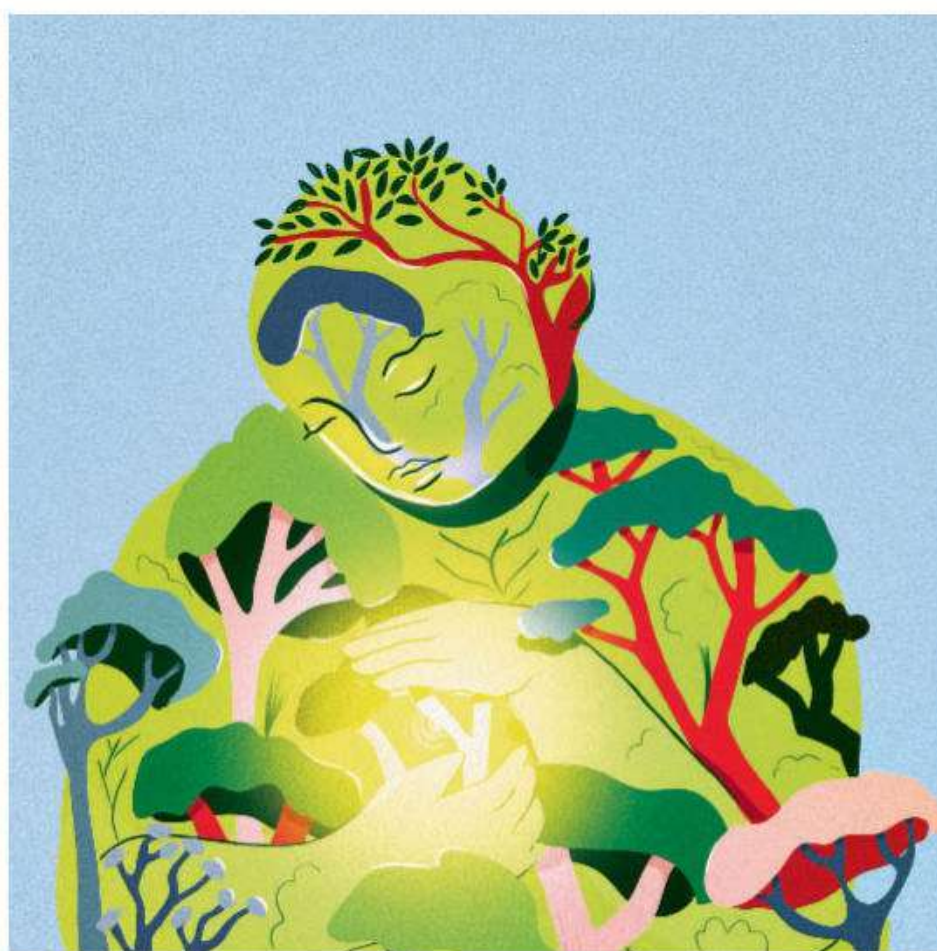
The trees of life

Forest ecosystems are under threat and replanting isn't enough. We need to understand them to save them, says **Jingjing Liang**

SINCE the 13th century, forests have been managed as sources of trees that can be processed into timber. More recently, with mounting concerns over climate change, they are often studied as potential carbon sinks because trees are capable of sequestering greenhouse gas emissions. But what remains largely unknown is the true relationship between a forest and the trees that make it up. While there is an international commitment to protecting biodiversity, a lack of knowledge about forests poses a huge obstacle to making effective conservation decisions.

With global attention drawn to increasing the number of trees as a means of climate change mitigation, highly publicised strategies such as the Million Tree Initiative, the Plant a Billion Trees scheme and the Trillion Tree Campaign have emerged. Overshadowed by these commendable feats is the degradation and deforestation of 10 million hectares of forests worldwide each year.

Many of the trees we are losing are in primary forests – a type of pristine ecosystem that offers irreplaceable ecological and socio-economic benefits, such as harbouring threatened flora and fauna, as well as underpinning the unique cultures and customs of Indigenous communities. Some have survived earthquakes, hurricanes, fires and other natural disasters over thousands of years,



but have been wiped off the face of the Earth in a short space of time due to adverse human impacts. Perhaps we can plant millions, billions or even trillions of trees, but those we are putting in the ground today can hardly make up for the forests we are losing, and very few of these trees will ever grow into a primary forest.

When a forest is regarded as simply a collection of trees, we miss the holistic value of its biodiversity. From uniform alpine and circumpolar forests to tropical rainforests that host a plethora of species, they are the most important global repository

of terrestrial biodiversity. When a forest is cut down, we also lose other living organisms from which we can draw new materials, processes, designs and inspiration to confront environmental, medical and engineering challenges in a world full of crises. For instance, in 2019, scientists discovered a new antibiotic in a Mexican tropical forest; hundreds of other potential pharmaceuticals are still waiting to be found.

To address the lack of knowledge about tree populations, my colleagues and I compiled a unique, ground-sourced forest database through the Global

Forest Biodiversity Initiative. Underpinned by complete tree-level survey records from more than 1 million sample plots across 110 countries and territories, it is a snapshot of forest ecosystems and allows us to estimate important attributes of forest biodiversity at a global level. One such attribute is the total number of tree species worldwide. According to our estimate, there are approximately 73,000 tree species on Earth, and more than 12 per cent of them haven't been documented yet. These findings remind us how little we understand our own planet.

What is still unknown is the number of tree species at a local level and how evenly trees are distributed among these species. Mapping them across the global forest range is vital for prioritising global conservation and detecting, monitoring and assessing the rate of extinction, as well as its impact on ecosystem functionality and human well-being.

To effectively protect forests, international communities must work together to address the disproportionate share of responsibilities between richer and poorer countries, since more than 90 per cent of the most diverse forests are in low-income nations. Together, we can truly begin to see the forest for the trees. ■



Jingjing Liang is a co-founder of the Global Forest Biodiversity Initiative

This changes everything

Web3 is a fantasy, but it can still hurt you The complexity and hype about the next, decentralised phase of the internet is increasingly breeding scams, writes **Annalee Newitz**



Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading

Isaac Fellman's novel *Dead Collections*, about vampire archivists in love.

What I'm watching

Severance, a new sci-fi show about office workers with brain implants.

What I'm working on

Writing a piece about fears of brainwashing during the cold war.

This column appears monthly. Up next week: David Robson

A FEW weeks ago, a couple named Heather Morgan and Ilya “Dutch” Lichtenstein were arrested in New York, accused of laundering \$4.5 billion in stolen bitcoin. Dubbed the “crypto couple”, their story quickly went viral. Not only was the scale of the pair’s alleged crime mind-boggling, but it soon emerged that Morgan makes bizarre rap videos under the name Razzlekhan, which feature her dancing on Wall Street and issuing advice like “be a goat, not a sheep”.

This is hardly the only weird news from the often shady world of crypto. There has been plenty of hype recently about non-fungible tokens (NFTs), unique cryptographic files that record ownership of digital objects, such as artworks. In mid-February, a scammer managed to steal 17 people’s NFT artworks, collectively worth \$2.9 million.

Meanwhile, a group of influencers who promoted the “SafeMoon token”, a cryptocurrency, to their followers are being sued for executing an alleged “pump and dump” scam. The influencers are accused of artificially “pumping” the value of SafeMoon, getting a tonne of people to buy it and then selling all their tokens at peak price, “dumping” their currency before its value plummeted.

What do these stories have in common, other than sounding like a season of *Black Mirror*? They are all dispatches from the frontier of Web3, a term that marketers and investors use to describe the next phase of the internet. In fact, they are just a tiny sample of hundreds of similar stories featured on Web3 Is Going Just Great, a blog that warns readers about the scammy side of cryptocurrencies, NFTs, blockchain applications and “metaverse” high jinks.

At the helm is software engineer Molly White, who has emerged over the past year as one of Web3’s smartest and best-informed critics.

If you are still wondering exactly what Web3 is, you certainly aren’t alone. The basic idea is that the next phase of the internet won’t be centralised, as it is now, dependent on a few big players like Meta. Instead, it will be decentralised, with payments and data stored on blockchains. The term was first introduced by Gavin Wood, who was the co-founder of popular blockchain project Ethereum.

“Web3 is the flying car of the internet, always on the cusp of widespread adoption but never quite getting there”

Although it is a major buzzword in the tech industry, Web3 is still mostly a futuristic fantasy – think of it as the flying car of the internet, always just on the cusp of widespread adoption but never quite getting there. I asked White to help me puzzle out what Web3 promises to be, and the unsavoury reality of what it currently is.

“A lot of so-called Web3 projects fall apart quickly under any scrutiny,” White told me by email. She first noticed this pattern in early 2021, when she was reading a lot of news about cryptocurrencies and other blockchain-related tech like NFTs. “I started to come across just an enormous amount of scams,” she said. “I realized that this was happening constantly, but no one was really collecting it in one place.”

Part of the appeal of Web3 Is Going Just Great is that it is simultaneously educational

and hilarious. White analyses recent news about scams and catastrophes in the Web3 world, with key terms highlighted so you can look up what a “bitcoin wallet” is, learn about NFT marketplaces or discover how a “cryptocurrency blender” works.

In the bottom-right corner of the page is a delightful feature called the Grift Counter. It is a text box surrounded by pixelated flames with a running total of the amount of money people have been swindled out of due to scams recorded on the site. At the time of writing, the total was \$8.4 billion.

White said her work is partly a form of activism, because Web3 scammers use the complexity of the technology to prey on people who are still figuring out what a blockchain is. “Even some of the biggest and most ‘legitimate’ platforms in this space do very little to educate their customers... and I think this is very intentional,” said White. These firms “would probably have fewer customers if every one of them actually knew what an NFT was”, she said.

White also wants to highlight how many ordinary people are becoming victims. She recalled a guy whose Bored Ape NFT was stolen last year. A few days later, the victim tweeted: “This was my kids college. My mortgage.” White said she couldn’t stop thinking about him.

Crucially, critics like White are also pushing back on the whole premise of Web3, pointing out that most of this so-called decentralised tech is actually centralised, in the hands of a bunch of shaky apps from start-ups and clueless influencers. And people are pouring their life savings into them.

So how is Web3 going? If you are a grifter, as White would put it, then it is going just great. ■

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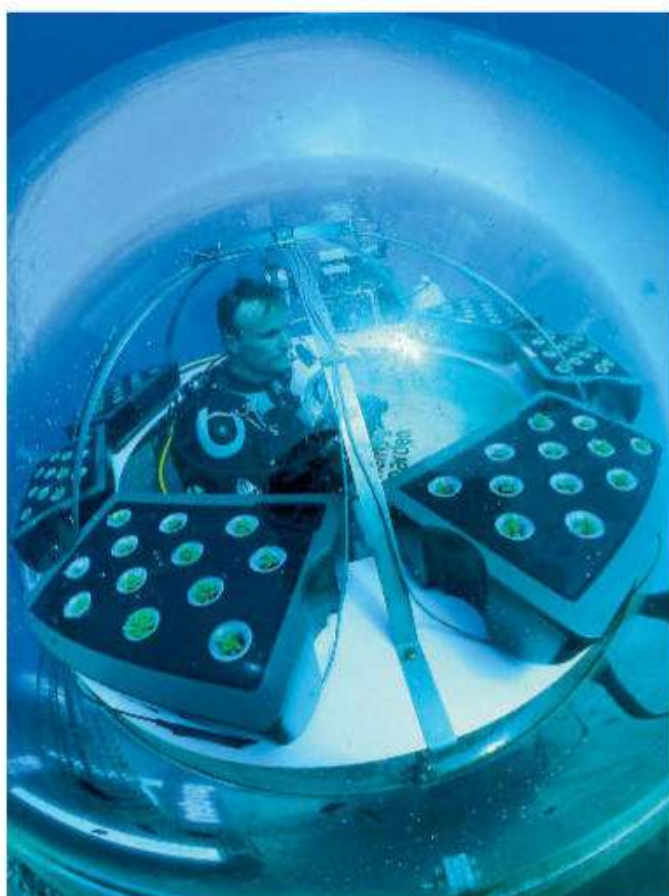






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Undersea beds



**Agency Nemo's Garden
by Ocean Reef Group**

THIS otherworldly, underwater environment is more than just a cool diving spot. It is a sunken farm for terrestrial plants. Called Nemo's Garden, it is located in the sea off Noli on the Italian Riviera and was created to explore the possibilities of novel agriculture.

The "garden" is a research project run by diving equipment company Ocean Reef Group. It is developing mostly hydroponic techniques, which don't require soil, for growing plants in six large underwater domes. These floating biospheres are largely self-sustaining systems that each hold about 2000 litres of air. They are secured at between 5 and 10 metres below the surface.

The combination of warming sunlight and cool seawater maintains plant-friendly humidity and warmth within the domes, with daytime air temperatures reaching 24 to 32°C. Other conditions, including carbon dioxide and oxygen levels, are closely monitored.

This approach has several advantages, claims Ocean Reef Group: it is somewhat independent of weather, and there are no parasites, so pesticides aren't needed. The team is still investigating which types of plant, including vegetables, are best suited to growing underwater. ■

Gege Li

Editor's pick

Fossil fuels seemed like a good innovation once

19 February, p 27

From Ben Craven, Edinburgh, UK

James Ball discusses some reasons why people are nervous about new technologies. Here is another: risk. Some technologies, such as the burning of fossil fuels, come back to bite us. We deploy new technologies globally and rapidly with no idea of the long-term consequences. The internet brings benefits, but it has worrying political consequences – the spread of misinformation, for example.

Governments urge ever more rapid innovation. But the faster we do this, the sooner we are going to hit upon an idea that turns out to be irretrievably and catastrophically bad. "It seemed like a good idea at the time" will be a deeply inadequate excuse.

Coral gardening is a stopgap worth having

5 February, p 27

From Arthur Dahl, Geneva, Switzerland

While Catherine Collins rightly highlights fossil fuel emissions and overfishing as the sources of coral reef destruction, rejecting coral gardening is like denying the usefulness of a bandage in protecting a wound while it heals, or cancer surgery while we lack a cure for the disease.

We need to save what we can of reef functioning in the hope that true solutions will come in time.

Did space-time not exist until we came along?

5 February, p 38

From Ton Smit,

Utrecht, The Netherlands

I can imagine that we humans influence space-time, but not that we create it, as you suggest in your new perspective on quantum reality. Who created space-time when humanity didn't exist?

I always had difficulty with Schrödinger's cat. For me, it is clear that the cat is either dead or alive. You just don't know which one it is. I don't grasp how not knowing something could create space-time realities. When I ask my friend to choose a number between 1 and 10 and he does that, but doesn't reveal his choice, then I don't believe that he is in a superposition of 10 states in space-time. I just don't know his choice. Or are space-time realities only created on a subatomic level?

A form of heating that could help the world

19 February, p 20

From Rob Saunders, Cranbrook, Kent, UK

Adam Vaughan's excellent review of ways of removing greenhouse gases from the air didn't mention biochar production, which could be deployed at scale.

Pyrolysing (heating at high temperatures) organic materials under anaerobic conditions creates charcoal, which is called biochar when pulverised to gravel or dust-sized pieces and used as a soil additive. Carbon compounds in biochar are dominated by fused aromatic ring structures that are intrinsically resistant to biodegradation and are thus stable for climatically useful timescales as a means of carbon sequestration.

Biochar is thought to enhance soils as a result of micro and nanostructures on the surface of the particles, providing microsites for soil bacteria and mineral exchange. The net effects on soils are generally positive, improving texture and nutrient availability.

A range of feedstocks could be used, such as waste wood, forestry thinnings, miscanthus grasses

and dry crop residues. Biochar offers a low-tech route to carbon removal that has minimal risk of subsequent leakage.

A reason to round on the circular economy

12 February, p 38

From Geoff Russell,

Adelaide, South Australia

To paraphrase the journalist H.L. Mencken, "for every complex problem there is an answer that is clear, simple, and wrong". So it is for materials and the circular economy.

Consider two options. Produce 350,000 tonnes of very sophisticated materials, fabricate them into solar panels, then mount on metal supports, perhaps with concrete footings. This will cover some 10,000 hectares of what could otherwise be wildlife habitat. It will produce little or no energy 70 to 90 per cent of the time.

In a circular economy, you would then collect all 350,000 tonnes (plus frames) every 25 years or so and take it back on trucks to factories to reprocess it at an enormous energy cost.

The alternative (non-circular) solution is to mine 200 tonnes of uranium annually and use it as fuel in fission reactors (plus a few thousand tonnes of metals to make the pressure vessel and generators). The reactors will last 80 years or more before they also can be (mostly) recycled. That isn't circular, but degrades very little land and has a tiny material flow by comparison.

From Richard Brown,

Huntly, Aberdeenshire, UK

I read again that 30 per cent of food is wasted. It is high time to bring back the pig to its rightful

role of converting food waste into edible protein and fat. I know that the veterinary profession, of which I am a part, has been against swill feeding for decades, but this must change and the government needs to set a framework so that pigs fed food waste are prioritised over modern intensive farming. This will cause large changes in the genetics and management of pigs.

Happiness is comfort or an inverse relationship

22 January, p 38

From Ken Jensen,

Gibsons, British Columbia, Canada

A particular nuance of happiness has been overlooked. In her novel *A Closed Eye*, Anita Brookner touches on it when one of her characters reflects thus: "Happiness was what young people wanted; at his age he knew that comfort was more important."

From David Strachan,

Llanbister, Powys, UK

After your look at happiness and the letters on it, I have found the formula for the elixir of happiness: Happiness = 1/unhappiness.

The real crisis is the number of people

Leader, 12 February

From Murray Upton,

Canberra, Australia

The state of Earth in 2022 is indeed in crisis, but tinkering with the economy isn't the answer. The elephant in the room that few people dare to mention publicly is overpopulation of the planet. This silence must change.

From Denis Watkins,

Truro, Cornwall, UK

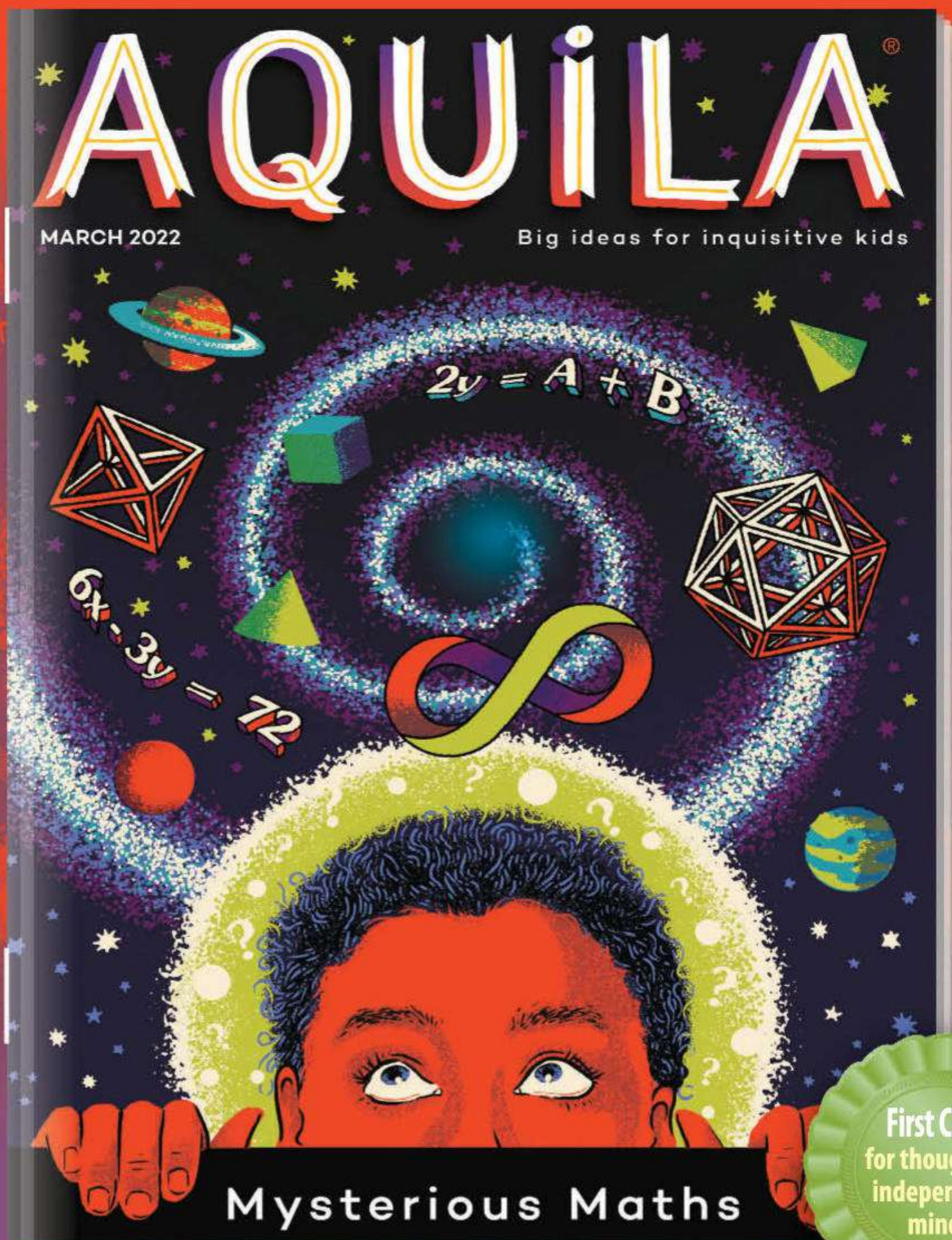
Geoff Harding (Letters, 19 February) fears for fertility in our polluted world. As a species, we seem incapable of restricting our encroachment on, and destruction of, all parts of the planet. Human sperm counts too low for fertility may be the best hope for a world that continues to be fit to live in. ■



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Battle of the smarts

In a world where artificial intelligence seems to be ready to take over, human common sense is far from obsolete, finds **Chen Ly**



Book

How to Stay Smart in a Smart World: Why human intelligence still beats algorithms

Gerd Gigerenzer

Allen Lane

IN THE 1950s, Herbert Simon – a political scientist and one of the founders of AI – declared that, once a computer could beat the best chess player in the world, machines would have reached the pinnacle of human intelligence. Just a few decades later, in 1997, the chess-playing computer Deep Blue beat world champion Garry Kasparov.

It was an impressive feat, but according to Gerd Gigerenzer, a psychologist at the Max Planck Institute for Human Development in Berlin, human minds don't need to worry just yet. In *How to Stay Smart in a Smart World*, he unpacks humanity's complicated relationship with artificial intelligence and digital technology. In an age where self-driving cars have been let loose on the roads, smart homes can anticipate and cater for our every need and websites seem to know our preferences better than we do, people tend to “assume the near-omniscience of artificial intelligence”, says Gigerenzer. But, he argues, AIs aren't as clever as you might think.

A 2015 study, for example, showed that even the smartest object-recognition system is easily fooled, confidently classifying meaningless patterns as objects with more than 99 per cent confidence. And at the 2017 UEFA Champions League final in Cardiff, UK, a face-recognition system matched the faces of 2470 football fans at the stadium and the city's

railway station to those of known criminals. This would have been useful but for 92 per cent of the matches turning out to be false alarms, despite the system being designed to be both more efficient and more reliable than humans.

There are good reasons why even the smartest systems fail, says Gigerenzer. Unlike chess, which has rules that are rigid and unchanging, the world of humans is squishy and inconsistent. In the face of real-world uncertainty, algorithms fall apart.

Here, we get to the crux of Gigerenzer's main argument: technology, at least as we know it today, could never replace humans because there is no algorithm for common sense. Knowing, but not truly understanding, leaves AI in the dark about what is really important.

Obviously, technology can be, and often is, useful. The voice and face-recognition software on smartphones are largely convenient and the fact that

YouTube seems to know what I want to watch saves the hassle of working it out for myself. Yet even if smart technology is mostly helpful, and is showing few signs of replacing us, Gigerenzer argues that we should still be aware of the dangers it can pose to our society.

“Knowing, but not truly understanding, leaves artificial intelligence in the dark about what is really important”

Digital technology has created an economy that trades on the exchange of personal data, which can be used against our best interests. Companies and political parties can purchase targeted adverts that subtly influence our online shopping choices and, even more nefariously, how we vote. “One might call this turn to an ad-based business model the ‘original sin’ of the internet,” writes Gigerenzer.

So, what can be done? Gigerenzer says that more transparency from tech firms and advertisers is vital. But

technology users also need to change our relationship with it. Rather than treating technology with unflinching awe or suspicion, we must cultivate a healthy dose of scepticism, he says. In an age where we seem to accept the rise of social media addiction, regular privacy breaches and the spread of misinformation as unavoidable downsides of internet use – even when they cause significant harm to society – it is perhaps time we took stock and reconsidered.

Using personal anecdotes, cutting-edge research and cautionary real-world tales, Gigerenzer deftly explains the limits and dangers of technology and AI. Occasionally, he uses extreme examples for the sake of making a point, and in places he blurs the lines between digital technology, smart technology, algorithms and AI, which muddies the waters. Nevertheless, the overall message of Gigerenzer's book still stands: in a world that increasingly relies on technology to make it function, human discernment is vital “to make the digital world a world we want to live in”. ■

Deep Blue's algorithms beat chess champion Garry Kasparov in 1997



STAN HONDA/AFP VIA GETTY IMAGES

A sexy singularity

Bigbug presents a strange and colourful world awash with predictable gags and innuendo, says **Gregory Wakeman**



Film

Bigbug

Jean-Pierre Jeunet

Netflix

JEAN-PIERRE JEUNET is widely regarded as one of the finest French film-makers of the past 30 years, having overseen the likes of *Delicatessen*, *A Very Long Engagement* and the much adored 2001 romantic comedy *Amélie*.

Bigbug is Jeunet's first feature film since 2013's *The Young and Prodigious T.S. Spivet* and his first French-language film since 2009's *Micmacs*. As fans of his work might expect, *Bigbug*, a futuristic sci-fi comedy, is downright bizarre.

Set in Paris in 2045, it takes place in a world where humans rely on robots to satisfy their every desire. Then four of Alice (Elsa Zylberstein)'s antiquated domestic robots decide to take her hostage, trapping her inside her home with her date Max (Stéphane de Groodt), his son Léo (Hélie Thonnat), her daughter Nina (Marysole Fertard), her ex-husband Victor (Youssef Hajdi) and his new girlfriend Jennifer (Claire Chust). Alice's nosy neighbour Françoise (Isabelle Nanty), who happens to be visiting along with her sex robot Greg (Alban Lenoir), also gets locked in.

What starts off as a minor inconvenience soon gets real when it emerges that the latest generation of robots, the Yonyx (all played by François Levantal), is trying to take over the world. As the Yonyx get closer to Alice's home, the humans start to turn against each other and the older robots, who may or may not be trying to keep them safe.

While Jeunet's previous films are similarly quirky, in *Bigbug*, he plays for much bawdier laughs. Sometimes, it works. A robot's



BRUNO CALVO/NETFLIX

Romance can get complicated when you are locked in with a sex robot while the androids attack

analysis of why Max is lying to Alice at the start of the film, for instance, suggests that Jeunet might be about to explore artificial intelligence in a unique and irreverent way.

Unfortunately, though, that level of insight never materialises, and this early scene is about as funny as *Bigbug* gets. Sure, Victor's increasing anger at being trapped inside is amusing to watch unfold, plus there are a handful of other slapstick moments that you can't help but smile at. But in general, it is surprising how predictable most of the gags are.

Filming began in October 2020, and it seems that Jeunet has tried to channel the mental and emotional struggles of quarantine during covid-19 and to critique both the world's reliance on technology and its infatuation with social media. Unfortunately, whatever message he is attempting to get across never really materialises. In its place are crude innuendos and sex jokes.

Some of Jeunet's more unusual creative decisions also make *Bigbug* less successful than it should be. It is jarring that, despite the mighty

financial backing of Netflix, the special effects look so cheap as to be genuinely off-putting. What's more, while the characters are almost entirely motivated by sex and the film includes several scenes that are definitely not suitable for children, the world Jeunet has created looks and feels cartoonish.

Alice's home, her clothes, her robots and even the flying cars all appear to have been inspired by *The Jetsons*, while the villainous Yonyx, who all look and act the same, could have been ripped straight from a 1970s comic book.

While these elements don't come close to gelling, Jeunet's light direction, bright colour palette and attractive set design do at least make *Bigbug* watchable. It helps that the script also takes some unexpected twists and turns that see the characters getting romantically entangled in ways that you might not initially expect.

But considering Jeunet's past cinematic triumphs, and after so long away from the camera, *Bigbug* just doesn't provide enough laughs or sufficient thematic depth to be anything other than disappointing. ■

Gregory Wakeman is a journalist based in Los Angeles

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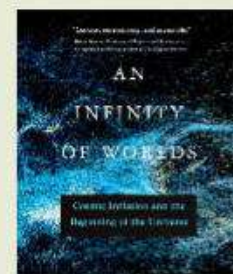
Watch

Upload, a sci-fi comedy that satirises the idea of a digital afterlife, returns for a second season. Created by Greg Daniels (*Parks and Recreation*, *Space Force*), the series will be available on Amazon Prime Video from 11 March.



Visit

New Scientist Live will be at Manchester Central and online from 12 March. With talks from over 40 speakers across four stages, there are also live, hands-on demonstrations and exhibitions. 14 March is dedicated to schools and home learners.



Read

An Infinity of Worlds may exist in the universe. In this eye-opening account of cosmic inflation, physicist Will Kinney points out that if this were true, it would raise difficult questions about what the cosmos actually is.

The games column

Post-pandemic zombies The apocalypse can be fun when you have parkour skills to help you explore your surroundings and escape the bad guys. But a lifeless storyline left me as cold as one of the undead, says **Jacob Aron**



Jacob Aron is New Scientist's deputy news editor. Follow him on Twitter @jjaron



TECHLAND

In *Dying Light 2*, a variant of a virus has turned people into zombies

streets, so it is tricky to get around outside, but easier to explore within. Dodging zombies has its rewards: you get bonus experience points, which you can use to upgrade your abilities, handy for venturing out at night and for surviving a zombie chase.

For reasons that are never properly explained, Aiden has expert parkour skills that allow him to scale buildings, jump across rooftops and generally dodge undesirable characters. In a strange game design decision, features that would usually be part of the basic move set in this kind of game (such as the ability to slide) require unlocking upgrades, so it takes a while to accumulate the full set of skills.

That is a shame, because this freedom of movement is probably the best thing about the game. I had great fun racing through the city, but beyond the obvious covid-19 links, the meat of the game is nothing you haven't seen before. Everything boils down to: go here, get this thing, kill these zombies, repeat.

As you explore the city, you get the opportunity to claim various locations, such as a water tower, for one of three factions: the slightly fascist Peacekeepers, the anarchic Renegades or the ordinary survivors. You get to pick a side, and Techland, the game's developer, goes big on the idea that which you choose matters to the (entirely forgettable) storyline. But two years into the pandemic, I was more inclined to stick with the ordinary survivors. It is hard not to sympathise with people who have lived through a world-altering disaster and are just trying their best to carry on existing. ■



Game

Dying Light 2 Stay Human

Techland

PC, PlayStation 4 and 5, Xbox One and Series X/S

Jacob also recommends...

Games

Mirror's Edge

DICE

PC, PlayStation 3, Xbox 360

In probably the best parkour game ever made, you play as Faith, a courier who traverses the rooftops of a futuristic city.

State of Decay

Undead Labs

PC, Xbox 360 and One

This zombie game puts you in charge of a whole post-apocalyptic community, so if one character succumbs to the horde, you can switch to play as another.

IN APRIL 2020, soon after the UK entered its first lockdown, I reviewed the zombie-packed *Resident Evil 3*, describing it as noticeably “pre-pandemic fiction”. Two years on, the pandemic is still going, and I am still playing zombie games. This time, it is *Dying Light 2 Stay Human*, and it is interesting to look at the game as a work of post-pandemic (mid-pandemic?) fiction.

It is a sequel to the 2015 game *Dying Light*, which saw a viral outbreak in the fictional Middle Eastern city of Harran turn people into zombies. The end of the game promised a cure to the disease, but as the introduction of *Dying Light 2* explains – and stop me if you have heard this before – a new variant of the virus emerged in 2021 and spread rapidly. The zombies took over and civilisation collapsed. Cheery stuff.

The game picks up the story in 2036, where you play as a survivor called Aiden Caldwell. After being bitten by a zombie, you enter one of the last remaining outposts of society, known only as the City. There, you discover that all of the

other survivors are also infected, but use a variety of tools to avoid zombification – hence the “Stay Human” part of the game's title.

Full zombies can't survive in sunlight, so City folk have set up ultraviolet lamps to hold back the infection. One of your early goals in the game is to acquire a wristband that provides an alert

“Aiden has expert parkour skills that allow him to scale buildings and dodge undesirable characters”

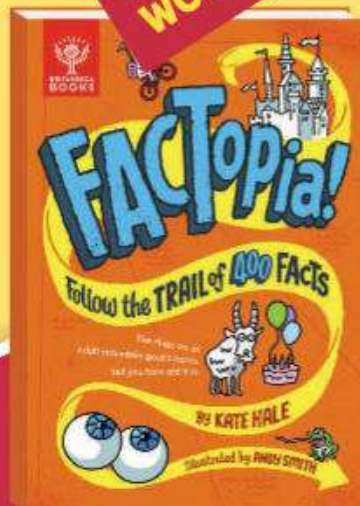
when you need a top-up of UV. Owning one of these wristbands is a condition of living in the City, perhaps a nod to the various covid passes that have been implemented around the world.

With a wristband secured, the game settles into a rhythm. By day, you are more or less safe from zombies outside (though not from roving bandits), although it is risky to enter derelict buildings, where the undead tend to gather. Then, at night, the zombies hit the

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Chemistry to change the world

Niftier ways to manipulate molecules are bringing us advances on fronts from sucking greenhouse gases from the air to inventing infinitely recyclable materials and even creating artificial life. **Katharine Sanderson** reveals seven of the most exciting innovations

Creating an artificial leaf

1 Our insatiable appetite for energy has got us into a mess, with the burning of fossil fuels releasing greenhouse gases that are heating the atmosphere. It is enough to make you envious of plants, which produce their own energy – through photosynthesis – in a way that actually uses up the greenhouse gas carbon dioxide. If we could learn to mimic this trick on a grand scale, it would enable us to effectively liquefy sunlight to create a clean, green fuel.

Unfortunately, photosynthesis is a tough chemical reaction to copy. It involves many processes, including capturing sunlight, splitting apart water molecules to yield protons, and joining these protons with carbon atoms from CO₂ to ultimately produce fuel in the form of sugars. In nature, these jobs are performed by proteins that have had hundreds of millions of years to evolve – and they still only manage to turn energy from sunlight into fuel with an efficiency of 1 per cent at best.

A decade ago, chemist Daniel Nocera at Harvard University made a big stride forwards when he developed catalysts based on nickel and cobalt that could break apart water. That is just one part of recreating photosynthesis, however, and progress has since stuttered.

Then people started to realise that instead of recreating photosynthesis from scratch,

we could combine the best bits of chemistry and biology in a bionic leaf. Such leaves typically employ materials that efficiently absorb sunlight as well as natural proteins that excel at stitching together fuel molecules. A team led by Erwin Reisner at the University of Cambridge recently used a material called a perovskite to gather light and coupled it with an enzyme called formate dehydrogenase. The resulting bionic leaf converts light into formate, a chemical that can be used in fuel cells, with almost 1 per cent efficiency – on a par with what nature can achieve.

Nocera has embraced a similar approach. In 2016, he unveiled a system in which his water-splitting catalysts produced protons and electrons and fed these to bioengineered bacteria. The set-up could use sunlight to turn CO₂ into fuel and biomass with an efficiency of almost 11 per cent. “We did a complete artificial photosynthesis that’s 10 to 100 times better than nature,” says Nocera.

This is one great challenge that chemists have more or less solved, then. “It’s not a chemistry problem, necessarily, any more,” says Nocera. “It’s not even a technology problem.” For him, the reason we aren’t all running our cars on fuel from bionic leaves has more to do with a lack of will to build the necessary infrastructure.

Building molecular machines that do useful jobs

2 During the industrial revolution, simple mechanisms like pistons and ratchets were combined to produce machines that could do the work of many people. The changes this brought were both positive and negative, but nobody denies how sweeping they were. It might be wise to keep that in mind today, as chemists develop molecular machines – devices made not of iron, but of atoms – which could be as disruptive as any steam engine.

Simple molecular machines have existed for about two decades. Early examples include molecular wheels that could move along an axle, creating a piston-like mechanism. Three pioneers of this work – Fraser Stoddart at Northwestern University in Illinois, Ben Feringa at the University of Groningen in the Netherlands and Jean-Pierre Sauvage at the University of Strasbourg, France – were recognised with a Nobel prize in 2016.

More useful machines are now being made and tested. A few years ago, James Tour at Rice University in Houston, Texas, and his colleagues created a molecular ➤





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machine that could drill through cell membranes. This allows it to open holes through which drugs could be delivered.

Such devices can be built on to create even more sophisticated machines. The potential is huge: after all, living things use biomolecular machines to do many useful jobs. Ribosomes, for example, are biomolecular machines that assemble proteins. They add molecules called amino acids together in specific sequences to create a vast array of amazing materials, from the keratin in fingernails to the disease-busting antibodies of our immune systems.

David Leigh at the University of Manchester, UK, has long been working on a synthetic version of the ribosome. His designs tend to be based on a ring-shaped molecule equipped with an “arm” that moves along a linear molecular track, picking up pieces along the way and joining them together. Last year, Leigh and his team linked two of these machines together so they could build a peptide with 10 amino acids, in a specific sequence.

For the moment, Leigh’s machines can’t go beyond what nature can do.

But that could change. Ribosomes only build with about 20 amino acids, but a synthetic ribosome could be designed to work with a far wider range of molecules. “We can use the whole of the periodic table,” says Leigh. “I think molecular machines are going to change how we do everything in terms of material design.”

“Molecular machines are going to change everything in terms of material design”

Sucking methane from the air

3 The warming of our planet is usually blamed on carbon dioxide, but there is another major greenhouse gas contributing to the havoc in our skies too: methane. There is far less methane being emitted into the atmosphere than CO₂, but during its first 20 years there, methane’s warming effect is more than 80 times greater.

As it is emitted from livestock and leaky pipes, methane also reacts with nitrous oxides to make the gas ozone close to Earth’s surface. Here, ozone causes people breathing problems and is linked to a million premature deaths globally each year.

If we could scrub the air of methane, it would help stop temperatures rising, buying us some time to reduce our other carbon emissions. For every billion tonnes of methane removed from the atmosphere, Earth’s surface temperature would be reduced by a roughly 0.2°C, according to recent estimates from Rob Jackson at Stanford University in California and his colleagues. “It’s not easy, but if we can work out the chemistry, I think it’s a fantastic opportunity,” says Jackson.

Technologies for capturing CO₂ have been around for years. The gas given off in power station flues can be trapped by binding it to



Designing powerful and sustainable batteries

solvents in a reversible chemical reaction, and that CO₂ can then be imprisoned deep underground. But those same solvents can't absorb methane as easily. One reason for this is that methane molecules are a different shape, meaning those solvent molecules don't pack around them so easily.

One solution is to forget about capturing methane and instead chemically convert it to CO₂. Releasing extra CO₂ into the air might sound foolish, but given how bad methane is, it may be a positive move. "Every molecule of methane released into the air eventually ends up as carbon dioxide anyway," says Jackson. "All we're trying to do is speed up the transition." Most US states are already using this idea to tackle methane leaking from landfill sites, using a cover impregnated with microbes that convert methane to CO₂.

Alternatively, we might employ zeolites, materials that are riddled with atomic-scale tunnels that molecules can fit inside. Certain zeolites can absorb methane and then catalyse a reaction that turns it into methanol, which can be used in the chemical industry. Chemists have already found hundreds of zeolites that do this job to some extent. This technology isn't mature, but Jackson thinks it has great promise.

4 If we are going to stop burning fossil fuels, it is critical that we have access to electricity from renewable sources like wind turbines and solar panels. But we can't rely on the wind blowing or the sun shining exactly when we need power. We need a way to store electricity – and in many cases that is going to mean batteries.

Yet batteries themselves aren't without their environmental problems. The rechargeable lithium-ion batteries in electric cars rely on lithium, among many other metals. Sizeable lithium reserves are found in only a few places: the element has to either be extracted from huge salt flats in the Atacama desert in South America, which involves using up vast amounts of water, or be obtained by environmentally destructive conventional mining of the mineral spodumene in China and Australia. This is one major reason why chemists want to design a more sustainable battery.

Lithium's job inside a battery is to carry charge from one side to another. It does this so well because its ions are so small. Their +1 electric charge

is crammed into a small space, meaning lithium batteries fit lots of power into a small, light package. But there are other contenders for this charge-carrying role. One is sodium, which has the same +1 charge as lithium and is only a little larger. It is also extremely easy to source, given that it is part of the salt in seawater. Sodium-ion batteries have to be larger to pack as much punch as their lithium cousins, but for some non-portable applications, like storing solar-generated electricity, that is fine. UK-based firm Faradion has supplied sodium-based batteries for heavy goods vehicles in India.

Fully charged

There are many more options for battery chemistry out there, however, including using other ions, such as magnesium. The trouble is, changing the charge carrier often means redesigning other parts of the battery too, so that everything works in synchrony.

Crucial components of all batteries are the electrodes, which in the case of lithium-ion batteries are made

➤



Making endlessly recyclable plastics

using cobalt. This metal is even more problematic than lithium, being mined in only one location, the Democratic Republic of the Congo, often by young children working in awful conditions.

Ideally, we would design new battery systems that work without cobalt. This involves trying out lots of combinations of materials to find the sweet spot of high performance and sustainability, a time-consuming process. Serena Cussen at the University of Sheffield, UK, has been experimenting with a way of making prototype electrodes in a microwave in just 20 minutes. It is much faster than the usual methods, but it will still probably take a lot of pings before we have the perfect battery.

5 One thing chemists do superbly is make bonds between atoms. We are now wading through the consequences of that success: plastic waste that ends up burned, landfilled or floating in the oceans.

Plastics are polymers, long chains of molecules linked by strong chemical bonds. This is why they can be hard to degrade or recycle. Snipping apart those chemical bonds, to return to the small molecular building blocks, is often a tricky chemical problem.

There has been varying success in dealing with the main plastics we use. The low-hanging fruit is polyethylene terephthalate (PET), which is used to make plastic bottles. It can simply be shredded and remoulded into fresh bottles. No chemists need apply.

It is a different story with most other important plastics. Take polyvinyl chloride (PVC), which is ubiquitous in double-glazed windows and plenty besides. "PVC's an absolute nightmare," says chemist Anthony Ryan at the University of Sheffield, UK. There is no known way to recycle it, and even if you did, you would end up with vinyl chloride, a toxic compound that can increase the risk of cancer.

One job for chemists, then, is to devise

new reactions that can break plastics into molecules that can be reused. Susannah Scott at the University of California, Santa Barbara, has recently had success doing this with polyolefins, a class of plastic that includes polyethylene. She developed a technique that uses a catalyst to break down these plastics into smaller molecules without having to use bucketloads of heat. These smaller molecules could be used in detergents, paints or pharmaceuticals.

We also need to design new plastics and plan from the start what will happen to them after they come to the end of their life. Chemists are starting to invent plastics that can be recycled infinitely or that break down into materials that nourish the soil.

One example is the plastic devised by Ting Xu at the University of California, Berkeley. Xu added tiny enzyme-containing capsules to the plastic. The material can be processed, heated and stretched into useful objects. But when its life is over, all you need do is soak the stuff in lukewarm water for a week or so. This releases the enzymes, which digest the plastic into small molecules. We will need plenty of new materials like this if we truly want to eliminate the scourge of plastic waste.



Automating chemical synthesis

6 Perhaps the most storied aspect of modern chemistry is total synthesis. This is the craft of taking simple molecules and stitching them together to make some complex molecule. It is the way many drugs have been discovered and it is seen almost as an art form. Synthetic chemists spend hours in the lab, mixing, stirring and purifying.

These days, though, chemists are beginning to think that the legwork could be automated, allowing us to quickly make large libraries of new molecules and test their properties. To this end, Andy Cooper at the University of Liverpool, UK, and his team have built a robot chemist. So far, they have used it to make molecules that could act as catalysts to speed up the production of hydrogen from water using sunlight. The robot then tests the performance of each potential catalyst. But it could be used to make and screen all kinds of chemicals.

Tech multinational IBM is also experimenting with automation. Its RoboRXN kits use a machine-learning algorithm to help design the synthesis of molecules, working from a training database of 3 million chemical reactions. Alessandra Toniato at IBM's research centre in Zurich, Switzerland, says the approach could be helpful for people who want to make new molecules but lack the equipment. "It can be used by students, maybe, to mean they have access to chemistry that they might not have in university," she says.

Lee Cronin at the University of Glasgow, UK, has the more ambitious plan of automating chemistry to the point where anyone can do it. The vision is for a sort of 3D printer for molecules. One way in which this could be useful would be to produce medicines in the aftermath of disasters, before supplies can be sent in.

Cronin already has a device he calls a chemputer that can automatically synthesise molecules. But it needs to be fed the instructions in machine-readable language. So Cronin is also building a database of digital chemical recipes. In 2020, he unveiled a system that can speed this up, digesting published chemical reports and turning them into digital instructions for the chemputer. At the height of the pandemic, Cronin's team even produced a digital recipe for remdesivir, an antiviral drug for treating covid-19 that has been subject to supply-chain problems.



Robot chemists, like this one at the University of Liverpool in the UK, can speed up chemical synthesis

PROFESSOR ANDREW COOPER, UNIVERSITY OF LIVERPOOL

Creating artificial life

7 How did Earth turn from a sterile ball of rock into a lush, green world of living things? This question of how life got started is one of the hardest of them all.

Still, we are inching closer to answering it. Several scientists have created things that approximate to life. Late last year, a team led by Josh Bongard at the University of Vermont reprogrammed frog skin cells into "xenobots". These groups of cells can swim and reproduce, working together to corral loose cells into new versions of themselves.

But if you drill right down to the heart of this question, you reach a bedrock of chemistry. How did a selection of inanimate molecules start joining together and replicating themselves? In the 1950s, chemists Stanley Miller and Harold Urey put a mixture of chemicals in a sealed jar and showed that amino acids, a key ingredient in living things, could be formed spontaneously. That was a big step, but it still doesn't tell us how those molecules formed a self-replicating system.

This is why chemists are interested in trying to recreate the moment that inanimate chemistry turned into the simplest possible life. There are billions of ways this could have happened. So Lee Cronin at the University of Glasgow, UK, is employing robots to help

investigate. He and his team have set up machines that combine a selection of simple substances – acids, inorganic minerals, carbon-based molecules – to react randomly. The outcome is analysed and then an algorithm helps the robot choose how to proceed. In this way, the robot can hunt through vast swathes of chemical space to see if any self-replicating systems emerge. Cronin thinks this automated strategy could overcome the biggest hurdle facing chemists in this field: "To remove the bias from the experimenter and see how evolutionary principles manifest in simple chemistry."

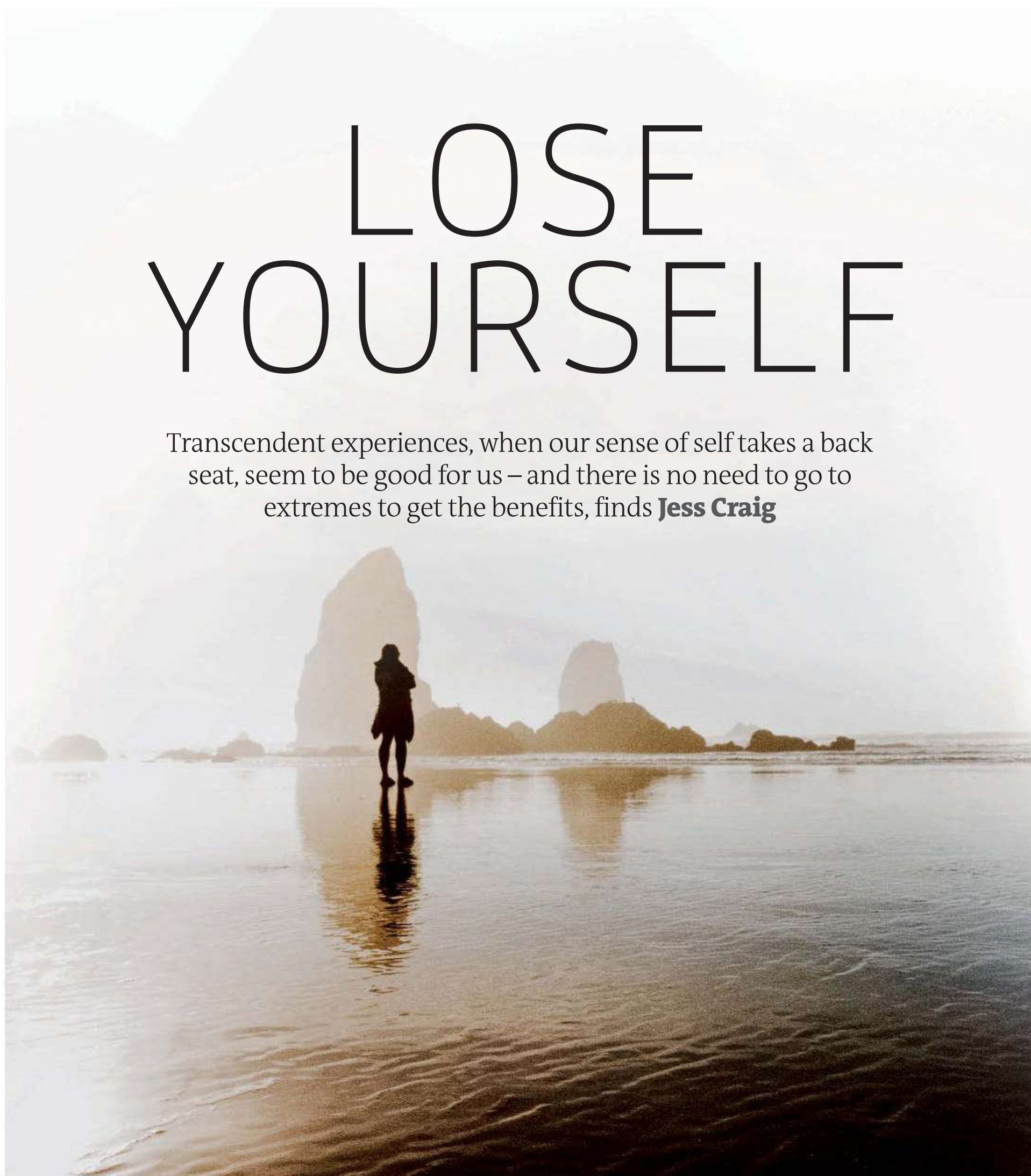
If chemists can recreate the emergence of life, we will be in a much better position to identify it on other planets. Their work could reveal particular ratios of molecules that would signal a self-replicating system, for example. Cronin has also developed a way of assigning molecules a score that reflects their complexity. Get beyond a certain score, and the molecule could only have arisen from a life-like process, he argues. "It will give a yes or no answer to if something is alive or not," he says. ■



Katharine Sanderson is a science journalist based in Cornwall, UK

LOSE YOURSELF

Transcendent experiences, when our sense of self takes a back seat, seem to be good for us – and there is no need to go to extremes to get the benefits, finds **Jess Craig**



SIMON SHIM/UNSPASH

A FEW years ago, psychiatrist Roland Griffiths published the results of some intriguing work with people facing imminent death. His team wanted to see if it was possible to reduce anxiety and depression in people diagnosed with terminal cancer by inducing an intense self-transcendent experience, in which a person's sense of self temporarily falls away.

Fifty-one people received two doses of the psychedelic psilocybin, previously shown experimentally by Griffiths and others to reliably induce what they call "mystical-type" experiences. Five weeks after the first dose, 63 per cent of them had a clinically significant reduction in depression symptoms and 51 per cent saw a reduction in anxiety symptoms. Five months later, many still had fewer symptoms.

Frederick Barrett, part of Griffiths's team at Johns Hopkins University in Maryland, says it isn't clear that the therapeutic effect was entirely down to the transcendent experience. But "a lot of people believe that is the case", he adds, "and I'm one of them".

If he is right, it is a striking example of how self-transcendent experiences, though temporary, can provide a lasting boost to well-being. And they don't have to be the intense experiences induced by psychedelics. Just staring in awe at magnificent trees or concentrating intensely on a challenging task also seem to have the capacity to make you happier, less stressed and kinder to others.

Now, some researchers are developing brain stimulation techniques that could induce self-transcendence, or at least accelerate the positive effects of mindfulness and meditation. So, should we all be seeking to lose ourselves more often? And if so, what is the best way to do it?

Self-transcendence is nothing new. Religious rituals and other cultural practices aiming to induce it have been part of the human experience throughout recorded history, and probably before. As something approaching a scientific discipline, however, the idea can be traced to 19th-century psychologist William James, who did experiments on himself to induce self-transcendent states. "We can experience union with something larger than ourselves and in that union find our greatest peace," he wrote.

Our understanding of the phenomenon has come on a bit since then. In a 2017 paper outlining different kinds of self-transcendent experience, David Yaden, a psychologist also at Johns Hopkins, defined them as "transient mental states of decreased self-salience and increased feelings of connectedness" – those moments when self-referential thoughts fade away such that you feel deeply at one with other people or your surroundings. Astronauts gazing back at Earth from outer space, for example, report feeling overwhelming emotion and a deep sense of oneness with humankind. Others report similar experiences during religious awakenings, near-death experiences, supernatural encounters, or the birth of a child.

But as Yaden makes clear, self-transcendent experiences exist on a spectrum of intensity: there are the most intense episodes, when your sense of self dissolves entirely, and there are less-intense versions such as the awe you feel when immersed in nature or the peace and feelings of well-being people report during mindfulness meditation.

In pretty much every case, these experiences appear to be good for us. A series of studies published in 2015, for instance, found that people exposed to awe-inducing stimuli such as towering Tasmanian eucalyptus trees or sweeping panoramic videos of mountains and forests were significantly more likely to report feeling less self-centred and to act more generously in a simulation than those exposed to control stimuli that didn't induce awe.

At the other end of the spectrum are the overwhelming feelings of transcendence induced in Griffiths's study on mystical experiences, in which 18 healthy adults were

administered a placebo or varying doses of psilocybin. The proportion of participants who reported having a mystical experience was greater among those who received the psychedelic and even more so among those who got a higher dose. That much you might expect. What is perhaps surprising is that those who received psilocybin reported improved mood and more positive attitudes and behaviours, and that those benefits persisted for 14 months after receiving the drug.

Thinking of you

What makes self-transcendent experiences so beneficial? At first blush, you might think it would be unsettling, even terrifying, to suddenly lose your sense of self. Indeed, many people report that intense transcendent experiences are "psychologically challenging and difficult", according to Yaden. For that reason, clinical trials aimed at inducing these states are done under close supervision. But there is ample evidence from clinical psychology to demonstrate that excessive self-focus can have negative effects – it is a hallmark of depression, for instance – which could explain why reducing that focus, even temporarily, can be helpful.

We have also learned a bit about what happens in the brain during self-transcendence. Imaging studies have repeatedly captured activation of the frontal lobe, part of the brain involved in attention and emotion, and reduced activity in the parietal lobe, which may be associated with the loss of the sense of self, says Andrew Newberg, a neuroscientist at Thomas Jefferson University Hospital in Pennsylvania. The default mode ➤

“There is ample evidence from clinical psychology that excessive self-focus can have negative effects”

network, an interconnected set of brain regions thought to be involved in imagination, daydreaming and perspective taking, also tends to be quietened during meditation and transcendent experiences. “It’s probably a very complex set of interactions that are occurring and, to some extent, that can’t be a surprise because of the sort of richness and diversity of these experiences,” says Newberg.

Whatever is going on inside our brains, the evidence suggests that we might all benefit from losing ourselves more often. For most people, psychedelics aren’t really an option. There is an ongoing revolution in their use for clinical therapy. In recent years, trials have demonstrated that drugs including MDMA, LSD and psilocybin can successfully reduce symptoms from a range of disorders from major depressive disorder and anxiety to chronic pain and post-traumatic stress disorder. However, while psychedelics induce intense transcendence more reliably than anything else, they remain illegal for recreational use in most countries.

Fortunately, there are other options. For low-intensity transcendent experiences, you can seek awe in nature. Or you can find activities that put you into a flow state, in which you become “completely absorbed in a highly rewarding activity”, says Richard Huskey at the University of California, Davis. Over the years, studies have shown that experiencing flow can variously help to prevent work-related depression and burnout, build resilience and improve well-being. A 2020 study on people being quarantined due to covid-19, for instance, found that those who engaged in activities that induced a flow state had significantly



Psilocybin, the active ingredient in magic mushrooms, may induce self-transcendence

improved well-being compared with those who didn’t experience flow.

Huskey says early work suggests flow leads to increased activity in brain regions involved in focus and decreased activation of brain regions associated with self-referential thinking and negative intrusive thoughts. “One potential reason flow might be useful for experiencing well-being is it can distract us from difficult things,” he says. “It essentially refocuses our attention away from negative thoughts and focuses them instead on something that’s intrinsically rewarding.” Or perhaps a flow state simply injects periods of “really intensely rewarding, intensely gratifying experiences” into our everyday life, he says, which in turn translates into higher levels of overall well-being.

What we know is that people induce a flow

state by engaging in activities in which they are highly skilled, but that are also challenging. Helpfully, people are generally pretty accurate at guessing what might bring on this state, says Huskey. “I can make a good inference that I’m probably not going to flow when snowboarding down a really easy run on the mountain, but I might feel it on a more difficult run.”

However, all such transcendent experiences, from flow states to mystical episodes induced by psychedelic drugs, are fleeting. Surely it would be better for us to get longer-lasting, or at least more habitual, self-transcendence. That brings us to mindfulness, typically defined as paying attention, on purpose, to the present moment.

For Jay Sanguinetti, a neuroscientist at the University of Arizona Center for Consciousness Studies, mindfulness may actually be a longer-term mental state. He views it as a sort of default state formed by habitual daily experiences and emotional responses. All day your brain is processing information and deciding how to act and respond, he says. “Sometimes that default state can tip into negative emotion, that’s depression. It can tip into anxiety, that’s anxiety disorder. So some people’s default state can become a problem.” Part of mindfulness training, he says, is to habitually change your thought processes about your body and the world around you so that default experience shifts towards a happier and more-balanced state of mind.

One mindfulness-based practice, known as equanimity training, involves viewing a series of emotionally triggering images. Participants track their response to each image, and if the response is negative, seek to redirect their attention to the task of viewing images. “That is changing how you’re emotionally present in the world, and people tend to feel better because they’re letting go of their triggers,” says Sanguinetti. In these days of pandemic and climate crisis, he adds, the ability to resist the sense of threat such scenarios pose may allow people to feel better on a day-to-day basis.

The problem is that when it comes to mindfulness, as with other forms of meditation, it can take years to perfect the techniques and get all the benefits. For instance, one study found that people

“The goal with transcranial focused ultrasound is to boost the positive effects of meditation”



Highly skilled, challenging activity can induce a state in which self-referential thoughts ebb away

TDCS, which uses small pulses of electricity rather than ultrasonic waves, helped induce flow in 32 participants playing video games. “If you apply this TDCS to medial parts of human participants’ brain, parts of the brain associated with, say, self-referential processing, it seems to have a causal impact on people’s ability to experience flow,” says Huskey. He urges caution, however, as this is the only study he knows of that has assessed an application of this technology to induce a flow state.

Sanguinetti similarly says there is a long way to go before we can stimulate the brain into transcendent states. He says his device is designed to accelerate and enhance mindfulness training, rather than induce self-transcendence. But he is bullish about the potential of such interventions. “I do really see the psychedelic science, the contemplative science and the neurotechnology movement, which is what I’m also part of, as creating interventions that help people get on the path to happiness,” he says.

The truth is that you might never experience self-transcendence, no matter how magnificent the view you are enjoying, how focused you are on something, or how much time you commit to perfecting meditation. But ultimately that isn’t a problem, according to Yaden, who argues that when it comes to improving well-being, self-transcendence doesn’t necessarily have to be the end goal.

“Practising meditation has a lot of benefits aside from a self-transcendent experience, and while a self-transcendent experience may come, and that is usually beneficial, I don’t think that should be the aim of someone engaging in the practice,” he says. “Rather than going out and trying to seek a mental state, specifically engage in things that are valued and virtuous activities.” Of course, if you find that you lose yourself for a moment, then all the better. ■

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries



Jess Craig is a science writer based in Nairobi, Kenya

who had practised meditation for at least three years had less reaction in the amygdala, a brain structure involved in our experience of emotion, when viewing happy or positive pictures compared with people who didn’t meditate. However, amygdala reactivity to negative pictures was only reduced in long-term meditators, those who had been practising for at least 10 years. The researchers concluded that prolonged meditation practice was required to fully regulate amygdala response to external stimuli. Another study found that decades of meditation can cause a thickening of parts of the brain associated with attention, interoception (your bodily sensations) and sensory processing.

In any case, self-transcendence through meditation is often only achieved by expert practitioners who have spent decades practising this. But there has been a push to see if the benefits of mindfulness and meditation can somehow be accelerated. In 2007, the Dalai Lama spoke about these challenges during a talk at the annual Society for Neuroscience conference in Washington DC. He asked the researchers in attendance to develop an intervention that could accelerate the path to transcendence so that he could spend less time meditating – and more people could enjoy the benefits.

Sanguinetti, who was in the audience that day, set out to do just that. Working with

the meditation teacher Shinzen Young, he pioneered a technique that involves targeting specific parts of the brain such as the right inferior frontal gyrus, an area implicated in mood and emotional regulation, with ultrasonic sound waves. The duo’s goal with the technique, now called transcranial focused ultrasound, is to boost the positive effects of meditation so that they could be more impactful faster.

Brain stimulation

The technology is still in its infancy, and yet the first studies are promising. In a randomised, double-blind controlled trial run by Sanguinetti, 48 participants received either a placebo or 30 seconds of transcranial focused ultrasound. The 24 people who received the stimulation reported significantly improved mood 20 and 30 minutes afterwards. In a second experiment, researchers carried out functional MRI scans to assess changes in brain activity before and after people underwent 2 minutes of the brain stimulation. They found significant changes in functional connectivity between different brain regions and notably decreased activity in the default mode network.

Something similar is also being mooted for the flow state. A 2019 study demonstrated that transcranial direct current stimulation, or



The slug hunter

Rory Mc Donnell studies the best ways to control the gastropods that damage gardens. He has found a surprisingly effective new method, he tells Brendan Knapp

SLUGS and snails may not look frightening, but don't be fooled. Poking out from beneath their slimy bodies is a tongue-like appendage called a radula, covered with thousands of tiny teeth. As gardeners know to their cost, this is a tool of extreme destructive power, which can shred stems and leaves like a grater. From dandelions to dahlias, few plants are safe.

Native slugs and snails are a vital part of ecosystems. They provide a food source to other animals, digest dead and decaying matter and eat pests. But invasive species can throw things off balance and it can be tough to control them.

Many gardeners have their own tried and trusted methods of attempting to make their plants safe from these gastropods, from the classic technique of circling the stem with crushed eggshells to the application of copper tape to flowerpots.

For professional growers, it isn't just their plants that are eaten up, but their profits too. Six years ago, grower communities in Oregon had had enough and representatives from the grass seed, vegetable and Christmas tree industries demanded the state act immediately to stop invasive slugs and snails.

In response, the state called in ecologist Rory Mc Donnell, one of the world's foremost

slug and snail experts. For the past few years, Mc Donnell, now based at Oregon State University, has been looking for ways to control invasive slugs and snails and has developed an effective method.

He tells *New Scientist* about the toll of invasive slugs and snails and why the best way to control them is almost certainly already in your kitchen.

Brendan Knapp: How much damage do invasive slugs and snails cause?

Rory Mc Donnell: Without question, it is billions of dollars every year. There was a study done by the Oregon Seed Council in 2012 that showed slugs alone cost the grass seed industry about \$60 million a year at the time. That is due to direct crop loss, the cost of molluscicide and the extra labour needed to sow more seeds. It's just mind-blowing to me. But that's the reason I have my position. And one thing that people often neglect about slugs and snails is that the damage they do isn't limited to just eating crops. Snail mucus or slug faeces on the crops decreases the quality rating, which in turn reduces the overall price of the produce when it goes to market.

And that's before we take into account the damage to people's gardens...

If you've got a nice vegetable garden, if you've got lettuces, carrots, potatoes, even peppers, they are definitely going to be taken out by slugs and snails.

It is coming up to spring in the northern hemisphere. Are slugs and snails going to be emerging to eat plants soon?

Over the winter, most slugs and snails hibernate and, yes, as it warms up in the spring, they come out to feed. Then they activate a summer hibernation phase called aestivation, where they seek shelter again – slugs below ground; snails above ground. And then they come out again in the autumn. Here in Oregon, once we get the first fall rains, that activates them to come out again. This pattern is pretty typical for here in the US, western Europe, the UK and Ireland. In more tropical areas, like Hawaii or the north of Australia, slugs and snails are active all the time.

How do people generally deal with invasive slugs and snails?

No matter where you go in the world, the number one approach is to use chemical pesticides, mostly metaldehyde. The trouble with this is that it is a neurotoxin and has caused a lot of deaths in dogs and cats that eat the pellets. In the UK, metaldehyde-based pellets are going to be made illegal in early 2022, though we can still legally use them in the US. Then there's iron phosphate, which is approved for use in organic systems. It's a fertiliser that kills slugs and snails, but there's some evidence it's also lethal to earthworms, which you really want to keep in your soil.

In parts of Europe, there's a nematode species that growers can use to get rid of slugs and snails. These nematodes are microscopic parasites that live in partnership with a particular type of bacteria. The nematodes find and penetrate slugs and snails and then literally vomit up a bacterial soup that's lethal to their hosts. The bacteria reproduce on the slug or snail and the nematode feeds on those bacteria. People in Europe can buy these nematodes in packets and sprinkle them around the garden – it's a good option because they kill slugs and snails very specifically.

Why aren't the nematodes used more widely?

That nematode was thought to only be found in Europe. If you're to introduce that to an area outside of Europe, there's a chance that it could become a pest as well. But my colleagues and I actually found this exact same nematode in California in 2014. We found it again in 2017 in Oregon. We've been doing a lot of work testing the lethality of these nematodes on slugs and snails to see if we can potentially use them as a biopesticide here in the Pacific Northwest. We want to be sure that pest species are killed and native non-pest species are not harmed.

You have another idea for slug control that uses something they find hopelessly attractive.

We have tested many different attractants: potatoes, lettuce, cabbage – we even had decomposing fruit and cat food extracts. We tested lots of different beers: Guinness, two IPAs, red ales and non-alcoholic beers. We found that hands down the best attractant

GAP PHOTOS/JONATHAN BUCKLEY



Snails have a tongue-like appendage called a radula, covered in sharp teeth, that can damage plants

is bread dough. During research last year in Oregon, Hawaii and Montana, we found the dough remained attractive for at least eight days and was significantly more attractive than a widely used metaldehyde-based bait. We see bread dough as a very simple and non-toxic approach to managing slugs and snails. Most people have flour and yeast in their homes. You just mix it together with water, leave the dough balls in your garden to attract the slugs and snails and hand collect them.

How effective is it?

In Montana, there's something called an eastern heath snail. It's a European snail, first discovered in the US in 2012, that is accidentally being brought into the country on railcars and shipping containers. We previously had contact with some scientific collaborators in Montana and tested cucumber there as an attractant and it worked very well. Then we reached out to them again to test our bread mix. We were blown away by the results. My associate went back the next morning

expecting to find maybe a handful of snails in each of the traps. She opened one trap and it was just full of snails. We collected and terminated more than 18,000 snails over two days. And I would say that was really a moment for us. We knew we were onto something.

Why does bread dough work so well?

We suspect it is something to do with the fermentation process. It's probably some volatile compounds being given off that are attracting the slugs and snails. Like many invertebrates, they communicate via chemicals, and have only basic vision. Chemistry rules their world. They're constantly picking up chemical signals in their environment, be it a food source, a snail or slug that's ready to mate or a predator. We don't know exactly what compounds in the dough are responsible though – we would like to get some funding to try to find out.

Can anyone use this at home?

We don't have a patent on this research. We want to make tools that people all over the world can use and help them with their pest management as well. I think bread dough is definitely a move in that direction. In places like sub-Saharan Africa, flour is widely available, as is yeast and water. Farmers can make up a batch of dough easily.

Do you have any slug and snail-hunting contraptions in your own garden?

I guess my yard looks like anybody else's, except, yes, I now use bread dough to attract the slugs. It seems to be working great, though the real test will be when spring arrives. Apart from that, one thing we have used out in the field is a camera to spot the snails in the dark. When we bought this in the early days of our research, we ended up getting it from a ghost-hunting website. That was an interesting thing to put on the expense form: a night-vision camera for ghost hunting. ■



Brendan Knapp is a science journalist based in Portland, Oregon

"We collected more than 18,000 snails over two days. That was really a moment for us"



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Science of gardening

Strawberry yields forever

Strawberries are tastier to eat when you grow your own, but they are also vulnerable. Here's how to succeed, says **Clare Wilson**



Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

Young strawberry plants

Pots or growbags of compost

An outdoor table

Netting to protect the plants from birds

THERE are plenty of reasons people grow their own fruit and vegetables: it is a satisfying outdoor hobby, it gets you some exercise and the produce has low food miles, usually making it good for the planet too.

Another reason is that many home-grown fruits and vegetables taste better than the ones on sale in shops. The difference is particularly noticeable for some types of produce, such as new potatoes, asparagus, tomatoes, strawberries, raspberries and blueberries.

There can be several explanations. One is that the varieties grown by farmers are often different to those sold for home growing. Farmers use varieties best able to be picked and transported to supermarkets without bruising or rotting, or those for which all the fruit reliably ripen at the same time, making for an easier harvest.

Recent work by researchers at the University of Florida into what makes for the tastiest tomatoes has found it is driven by differences in sugar and acidity, as well as numerous “volatiles” – biochemicals that are in gas form at room temperatures. As we chew and swallow the flesh of a tomato, these aromatic compounds reach the nose via the back of the throat; what we think of as the tomato's taste is really a mixture of its taste and smell.

The same is true for strawberries, a crop renowned for sometimes having disappointing flavour when bought from a shop.



GAP PHOTOS/JULIA BOULTON

A key problem for commercial growers is that these fruits may be harvested before they are fully ripe – when volatiles called esters are at their peak – or the fruit gets too bruised during transportation. Once picked, levels of sugars, acids and volatiles in the fruit start to decline, so it is really worth growing them at home or visiting a pick-your-own farm.

I have to admit, strawberries can be hard plants to get much of a crop from. As they lie close to the ground, they can be snaffled by slugs (see page 48), mice and birds, and can also get splashed by rain and soil, which encourages rot.

I have better luck when I grow them in pots sited on shelves in a greenhouse or fruit cage, which keeps them out of harm's way. An alternative is to use growbags

or pots placed on an outdoor table, or hanging baskets – you just need to put netting over the plant when the fruits start turning red.

Not all the tiny, green, immature fruits that form will survive and mature into ripe, red fruit, but those that do are worth the effort.

In a temperate climate like the UK's, pick strawberries during the warmest part of the day, when their volatiles peak.

Keeping them in the fridge hastens their loss of taste, but storing them at room temperature will see them quickly becoming mushy. There is nothing for it but to eat them straight away, ideally right off the plant. ■

Science of gardening appears every four weeks

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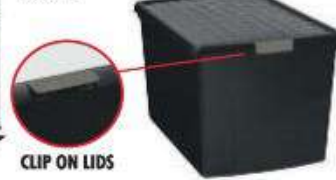


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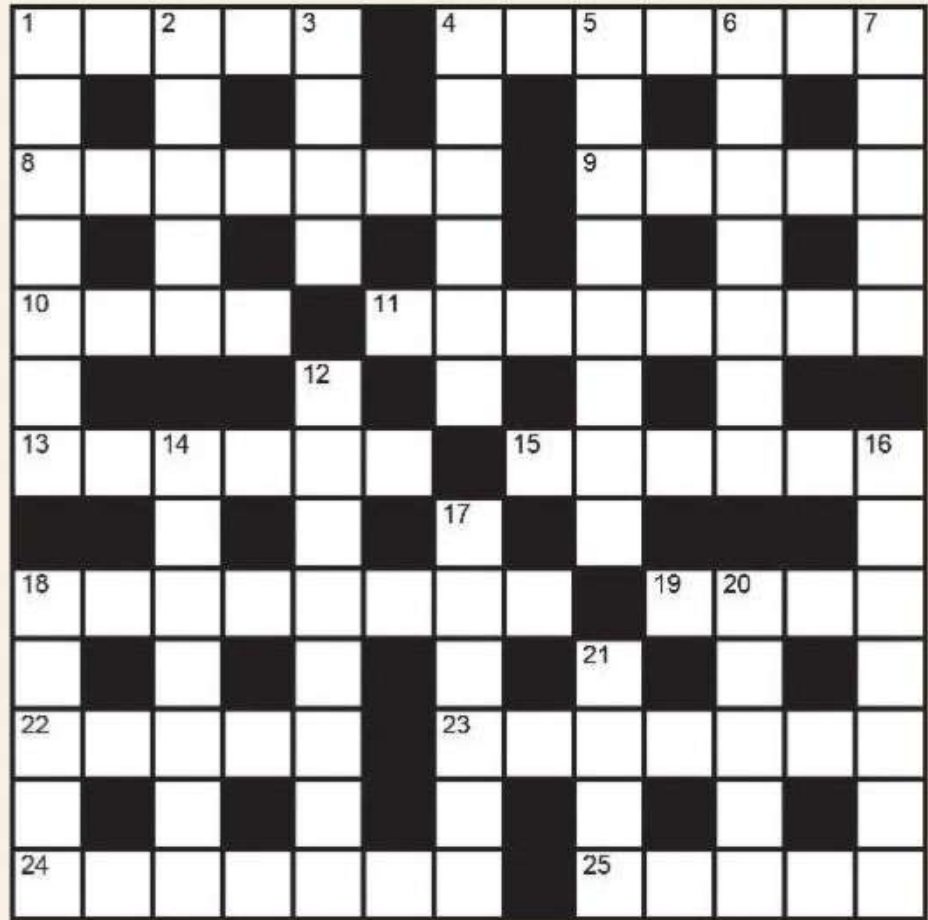
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Cryptic crossword #78 *Set by Rasa*



**Scribble
zone**

Answers, and
the next quick
crossword,
next week

ACROSS

- 1** Erase front of thin symbol of force (5)
4 Linger protectively around an old house (7)
8 Material stretched across former lover at hearing (7)
9 I won't break down reflected subatomic particle (5)
10 Takes home lepidopterist's tools (4)
11 Animal that grazes pre-run (8)
13 Star, apparently single, goes off with a Conservative from the east (6)
15 Male and female keep donkey by one cluster of mountains (6)
18 Break in to test mucus-like cave formation (8)
19 Insect page, back at the beginning (4)
22 Seize rogue offering way to achieve weight loss? (4,1)
23 Once again accept awkward maître d' (7)
24 Extremely dirty and disgusting set of rulers (7)
25 Go hunting bird of prey east of Puerto Rico (5)

DOWN

- 1** As I snare bats, Cam taking morning off (7)
2 Sorta irregular cut of beef (5)
3 Audibly judged what toddlers do at the seaside (4)
4 Curse Janet's limitless flammable liquid (6)
5 For example, count guy from Group 18? (8)
6 Regularly avoids companies keeping uranium flowing slowly (7)
7 Wash out number in jeans measurement (5)
12 Five set goal, bucking potential differences (8)
14 Athletic activity nearly tore highlander's purse (7)
16 Assembled craft with a large, self-repeating pattern (7)
17 Robust research project involving gas constant (6)
18 In a way, classified final letter supporting International System of Units (5)
20 Dance band initially carried by fancy car (5)
21 Pair of Canadians and politician pitch tents (4)



Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #141

- 1** What name is given to the study of recurrent natural events linked to climate, such as plants flowering or bird migrations?
- 2** How many mathematical problems did David Hilbert designate as challenges to be solved in the 20th century?
- 3** Which genus of bacterium was named for the grape-like clusters it forms?
- 4** How many stable, naturally occurring isotopes of cobalt are there?
- 5** In which US state is the Very Large Array, a radio-astronomy observatory?

Answers on page 55

Puzzle

set by Brian Hobbs

#157 Weather or not

At Shady Hills retirement home, Ike and Eileen are arguing over weather predictions.

"I'm telling you, Eileen, it's going to rain tomorrow and the next day, and then it won't rain on the third day."

"Balderdash, Ike. The way my knee is acting up, I'm sure that it won't rain tomorrow, but it will rain for the following two days. I'll bet my Monday night cheesecake on it."

"I'll take that bet. But what if we're both wrong?"

"Then we'll just keep waiting until there are three consecutive days that match one of our predictions."

Two of the staff overhear the conversation. "This time of year, there's a 50-50 chance that it will rain on any given day," says one, "so I guess their chances are even."

"You're right about the rain," says the other. "But even so, I think one of them has a much better chance of winning."

Which one, and why?

Solution next week

UV glow

Why do only some materials glow under UV light? For instance, when I shine my UV torch at a packet, only the price ticket glows bright blue.

Mike Follows

*Sutton Coldfield,
West Midlands, UK*

An atom can be visualised like a solar system, with electrons orbiting the nucleus, similar to the way that planets orbit our sun. However, only certain orbits are allowed, associated with certain energy levels. Only photons with a specific energy can be absorbed or emitted by an electron in order to allow it to jump to a higher energy level or fall to a lower one. The energy levels are like steps on a ladder, but with unequal spaces between the rungs.

When UV light is shone on a fluorescent material, the electrons in the atoms jump up at least two energy levels. Instead of falling straight back down to its original energy level and emitting a UV photon, which we would be unable

“In phosphorescent materials, there is a delay of up to 12 hours for the electrons to return to their original energy level”

to see, each drops back one energy level at a time. These transitions result in the emission of lower-energy photons, with at least one corresponding to visible light. Often, the other photons emitted will be in the infrared, representing even lower energies, though the total energy emitted will equal the total energy absorbed by the material.

Phosphorescent materials behave in a similar way except that there is a delay of up to 12 hours for the electrons to return to their original energy level. Such substances are often used in glow-in-the-dark paint and in signs to guide passengers when the cabin of an aircraft is in darkness.



SHUTTERSTOCK/FOTOKOSTIC

This week's new questions

Feed the world How many humans would be alive today if agriculture had never been invented? *Derek Johnson, Moreton in Marsh, Gloucestershire, UK*

Heated debate My partner insists that food cooked in a microwave tastes inferior to that cooked conventionally, but I disagree. Is there really a difference? *Kevin Halford, Pelt, Belgium*

Future archive

I want to preserve scenes from my childhood (currently on DVDs) for at least the next 100 years. With technology progressing so rapidly, what is the best format for this? (continued)

Cedric Lynch

Potters Bar, Hertfordshire, UK

Regarding Jane Lilley's letter in response to this question (29 January), if you put something on paper, you have to be careful what you write or print it with.

I had a problem with labels that were printed or written in ballpoint pen that faded away in a workshop with a large window. I did some research into this and found that most modern printing and writing

inks are now synthetic dyes that can fade when exposed to light.

In order to last, you need “permanent” ink. One example is Indian ink (this was actually invented in China thousands of years ago, but first found its way to Europe via India), which is a colloidal suspension of carbon. Another type is based on ferrous tannate that, once on the paper, oxidises to form insoluble ferric tannate.

In response to Lilley's other point, about microfiches being unreadable, this isn't a serious problem. In the 1990s, I had a colleague who bought a motorcycle that needed its engine rebuilding. The manufacturer was able to supply a workshop manual, but only in microfiche form.

If humanity had never invented agriculture, how many people would there be today?

We built a microfiche reader in a few days from a couple of lenses, a light bulb and some plywood. This projected the microfiches, greatly enlarged, onto a screen. It was well worth it because the motorcycle turned out to be a real gem.

David Holdsworth

Settle, North Yorkshire, UK

I would like to present a cautionary tale about storing anything in paper format.

In the late 60s and early 70s, I was involved with the construction of a multi-access operating system for an early computer called the English Electric KDF9. We were proud of this system, and when our machine stopped being used in the mid-70s, the source code was printed out and delivered to a university library for safekeeping.

In the early 2000s, a group of us “rebuilt” the KDF9 so as to provide meaningful preservation of one of its systems. This was successful, and led to the desire to emulate the whole multi-access system, thus preserving 1970s-style computing as a museum exhibit. I approached the library for access to the source code printout, but it had disappeared.

Paper is bulky and although it may physically survive for centuries, it also needs to be housed somewhere with a continuous desire for its survival. At some point, the printout must have seemed inconvenient and of dubious value to someone who had a better use for the space that it occupied. You only need to make this flawed decision once and the material is lost forever.

Tony Green

Ipswich, Suffolk, UK

One important thing to consider when future-proofing video, audio and images is to use a lossless compression codec that preserves all the information, such as lossless JPEG-2000 (for



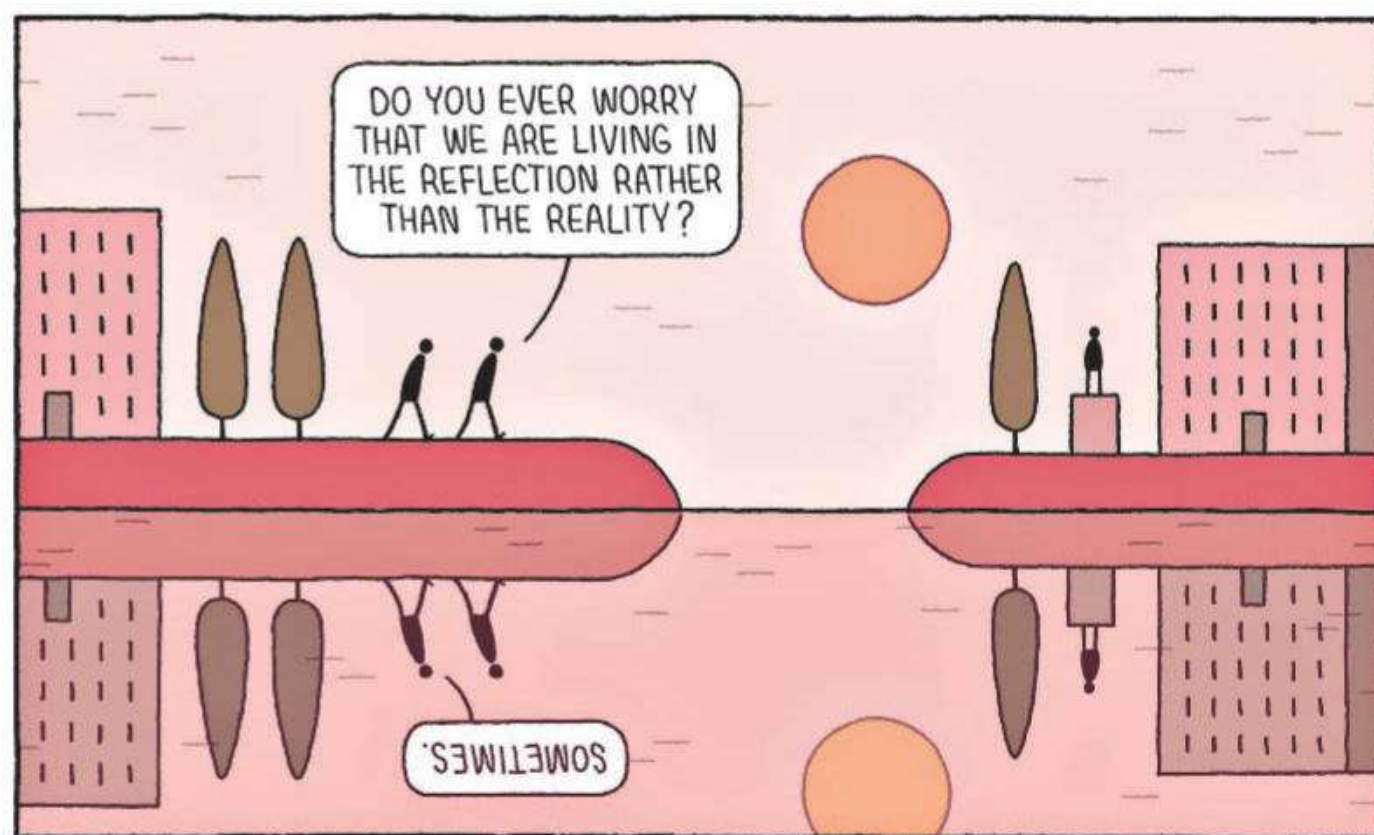
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Tom Gauld
for *New Scientist*



video), FLAC (for audio) or lossless WebP (for images).

Whatever format you choose for your archive, there is always the chance it may become unusable at some time in the future. But before it does, it should be possible to convert it to the next format. Using a lossless codec will ensure that there is no reduction in quality, no matter how many times the archive is converted. Lossy formats, such as MP4, MP3 or JPEG, will deteriorate each time they are converted to a new format. The lossless formats take up much more disc space, but will make it far more likely that your memories will be preserved for the future.

Into the void

The universe is expanding, but what exactly is it expanding into? (continued)

Colm Keenan
Cramlington, Northumberland, UK
Perhaps the universe isn't expanding. What if it is the yardstick we use to measure

"If I were a 2D ant in the boundary of an expanding sphere, wouldn't the distance between particles in my body increase too?"

it that is contracting, and in some absolute sense the universe remains the same size, only seeming to expand because of the way we assume we can measure it?

Andy Howe
Sheffield, UK

Further to the previous correspondence (15 January), it is worth noting that if the universe is infinite, it must always have been infinite, including the impossibly dense seed of the big bang. The subsequent expansion merely renders it "more infinite", even accepting that it has nothing to expand into. (My head hurts...)

A flat, infinite universe beyond our observable region is a popular option among cosmologists, as is indeed apparent from articles in *New Scientist*, but this couldn't

have formed from a finite universe that had undergone inflation at an infinite speed.

Patrick Verguet
Besançon, France

Despite its apparent simplicity, I find myself confused by the classic analogy for an expanding universe as the surface of an inflating balloon. If I were a 2D ant walking within the boundary of an expanding sphere, why wouldn't the distance between the elementary particles composing my body increase as well and my body itself inflate?

Pauline Fothergill
Pocklington, East Yorkshire, UK
May I add my mother's perspective on this question? As an inquisitive preschooler, I remember asking her: "What is the sky actually in?" She looked thoughtful, then eventually said: "Our brains are not big enough for us to understand this."

I always hoped that, as I grew, I would find an answer – but clearly my dear old mum was right! ■

Answers

Quick quiz #141 Answers

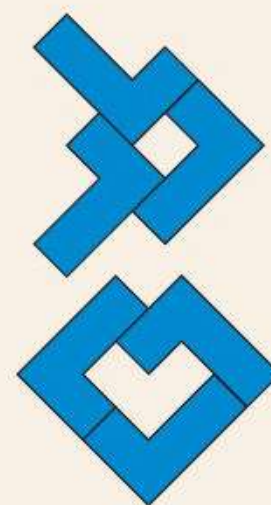
- 1 Phenology
- 2 23
- 3 *Staphylococcus*, from the Greek word *staphyle*, meaning "bunch of grapes"
- 4 One: cobalt-59
- 5 New Mexico

Quick crossword #102 Answers

ACROSS 1 Porphyria, 6 Quack, 9 Pylorus, 10 Aniline, 11 Iritis, 12 Stitches, 14 Edge, 15 Dental gold, 18 Locomotion, 20 Spit, 23 Davy lamp, 24 Go bang, 26 Retweet, 27 In utero, 28 Chert, 29 Endoscope

DOWN 1 Popliteal, 2 Rolling, 3 Hermit, 4 Rash, 5 Adaptation, 6 Quintile, 7 Atishoo, 8 Knees, 13 Centimetre, 16 Dataglove, 17 Smallest, 19 Cuvette, 21 Placebo, 22 Pop-ups, 23 Dirac, 25 Bird

#156 L of a puzzle Solutions



Here are the two symmetrical ways of putting the three L-shaped tetronimo together. The first is shaped a little like a fish; the second resembles a heart.

The order of not things

Cambridge – of Cambridgeshire, not Massachusetts, before anyone jumps in – is famed as the academic home of Ludwig Wittgenstein, Bertrand Russell and G. E. Moore, three philosophers who did much to elucidate, not to say obfuscate, language, logic and meaning. It is very much in their spirit, we assume, that Cambridge City Council recently advertised an extra rubbish bin collection following staff absences, stating “bins will be collected in the order in which they were previously not collected”.

“Is it quantum mechanics then that enables us to determine the order in which things don’t happen?” asks Alison Litherland, we imagine hovering indecisively over her bins. Quite possibly. Our starting point must be the following question: if a bin isn’t collected, but no one sees it not collected, has it been not collected at all?

In purely practical terms, the only way of finding out is by looking in the bin, making this a particularly pure instantiation of Erwin Schrödinger’s cat paradox. Maybe Schrödinger’s trash didn’t have quite the same ring to it. As far as your problem goes, Alison, we fear that repeated measurement of identical bins may allow you to build up a picture of when it wasn’t collected, but this will only have statistical validity.

Poet didn’t know it

Feedback is delighted to find, while searching for something else, that the physicist James Clerk Maxwell (died 1879) is listed as an author on the *New Scientist* website (born circa 1996).

Further investigation reveals a series of poems published by Maxwell in these pages in 2011. We are somewhat lacking context, but his *Valentine By a Telegraph Clerk (Male) to a Telegraph Clerk (Female)* bears rereading, with its culminating verse: “Through many a volt the weber flew,/And clicked this answer back to me;/I am thy farad staunch and true,/Charged to a volt with love for thee.”

Twisteddoodles for New Scientist



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Consideration of items sent in the post will be delayed

Sweet, if of its time. Following our musings on how old the internet thinks you can be (26 February), at 180, we may have found our oldest contributor.

Standard elephants

Metrologists at the International Bureau of Weights and Measures in Paris may still be basking in the replacement, in 2019, of the international prototype kilogram – a platinum-iridium hulk that would feel exactly like 1 kilogram if dropped on your foot – by a fancy-schmantzy definition in terms of various physical constants. But as regular Feedback readers know, they are missing the... in the room. The elephant is well-established as the actual international standard unit of mass.

Proof positive, a report from *The Hamilton Spectator* in Ontario,

Canada, sent in by Doug Thomson. A clean-up after storms there in January required the removal of “145,000 tonnes of snow – about 20,000 large, frozen elephants worth”. We can only imagine the difficulties of dealing with these homesick and discomfited beasts. The icing on the elephants clearly adds something to their weight, as we conventionally take an adult male African bush elephant to weigh about 6 tonnes.

Even as we hear calls for a standard prototype elephant kept under glass somewhere growing louder, news reaches us of a breakaway movement in New South Wales, Australia. Many of you highlight news of the seizure of 9.7 hectares’ worth of illicitly grown tobacco at Koraleigh “weighing the equivalent of 13 bulldozers”.

How many bulldozers of tobacco fit into Sydney Harbour, we wonder.

Meanwhile, Brian Horton consults the delightful website “What Things Weigh” to find bulldozers range from a baby 8 (good old non-metric) tons to a fully grown 180 tons. Suffice to say, the amount of tobacco seized at Koraleigh was some 42 standard elephants.

His mummy’s voice

The interwebs have delighted themselves recently at a story first reported by *New Scientist* in 2020, that researchers have recreated the voice of an Egyptian mummy held at Leeds City Museum, UK.

The experience is slightly hard to reproduce on the printed page, but oddly, in some of the clips now circulating, the mummy is clearly saying “UUUUGRRH”, whereas two years ago it was a far more refined “EEEEERGH”. Mummies could presumably have made more than one sound, says a colleague – not unreasonably, with the qualification “when alive”. “This is the replication crisis writ large,” says another, damningly.

Vive la résistance!

Much as we try to stop buttered toast falling on our pages, right side up or no, still it rains down. But we are in a philosophical frame of mind, so we are grateful to J. Feralco for the reminder of a corollary to Murphy’s Law, first established by humorist Paul Jennings in the 1940s: “The chance of the bread falling with the buttered side down is directly proportional to the cost of the carpet.”

This came as part of his Report on Resistentialism, a school of philosophy encapsulated by the phrase “*Les choses sont contre nous*” – “things are against us” – established on Paris’s Left Bank by “bespectacled, betrousered, two-eyed” thinker Pierre-Marie Ventre. Resistentialism holds that there are limits to the sway humans can hold in a world of largely hostile, uncooperative things. It is worth rummaging around for the whole essay online as a parable for These Uncertain Times. ■

"I'd got used to poor hearing but what technology can do is incredible"

Ian Fitzgerald,
Amplifon customer

Deaf in one ear since birth, the dad-of-two had spent all his life turning to one side during conversations after he was told nothing could be done to improve his hearing. That was before he went to Amplifon, where his audiologist used Bluetooth technology to solve his problem.

With no hearing in his right ear, Ian 59, had learnt to live with the problem, but that's not to say he found it easy to cope with. He'd had hearing aids before but there was no device that would have restored the hearing he'd never had.

After some time, Ian decided to have a free trial of some Amplifon hearing aids. As his ears were narrow, the audiologist arranged for the hearing aids to be shaped so they were a perfect fit. "It's like I've been transported into another world where I can hear everything so much more clearly," he says. "I don't think people can quite understand what a difference it can make to your life when you can hear so much better and pick up things you couldn't before."

Ian can also link the hearing aids to his iPhone, so the sound comes straight into his ears when he's talking on the phone. "Some people haven't even noticed I'm wearing hearing aids which is good because it shows that they are quite small and don't stand out." Ian says he'd recommend Amplifon to anyone. "I'd just got used to dealing with poor hearing for 59 years but what technology can do today is incredible. I'd say definitely try Amplifon because you don't lose anything by seeing what they can do for you."



Ian's hearing loss
made social situations
frustrating.

Sue Taylor,
Amplifon customer

I can now hear the birds sing

Sue Taylor struggled to hear at work, but her previous hearing aids still didn't correct the problem.

In her fifties, pharmacy dispenser Sue thought she was too young to be suffering from hearing loss.

The problems carried on at home, with Sue often unable to hear what her husband and daughter were saying. "I'd always have the TV turned up loud too."

Sue was referred for a hearing test and as a result, she was given hearing aids that still didn't correct the problem and her difficulties remained.

When daughter Kelly suggested she see an audiologist at Amplifon, she was amazed at the difference. The audiologist gave Sue a free in-depth hearing test using pioneering technology to pinpoint exactly what she needed.

After recommending a pair of hearing aids, Sue's audiologist offered her a free trial so she could test them out at home and at work.

Now in her sixties, she has found that she can enjoy going to restaurants, to the theatre and to concerts with her husband again.

"We don't need the TV up as loud now because I can stream it straight to my hearing aids," she says. Sue urges anyone who thinks that they may have a hearing problem to seek help from Amplifon. "I just wish I'd seen them years ago," she adds.

"I would recommend
Amplifon without
a doubt."

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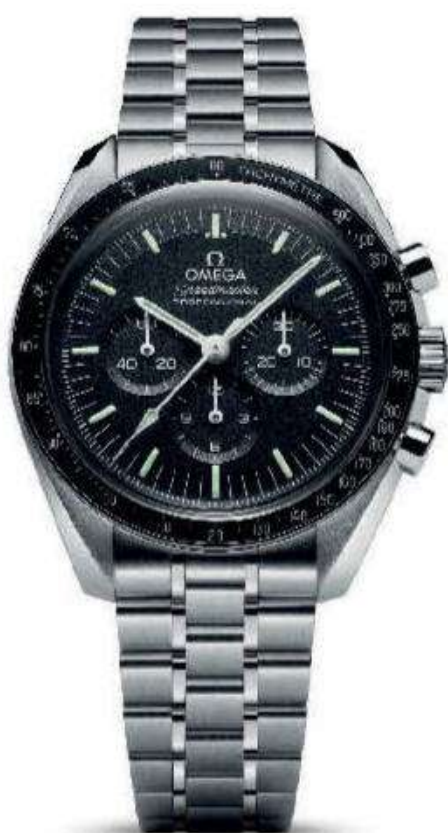
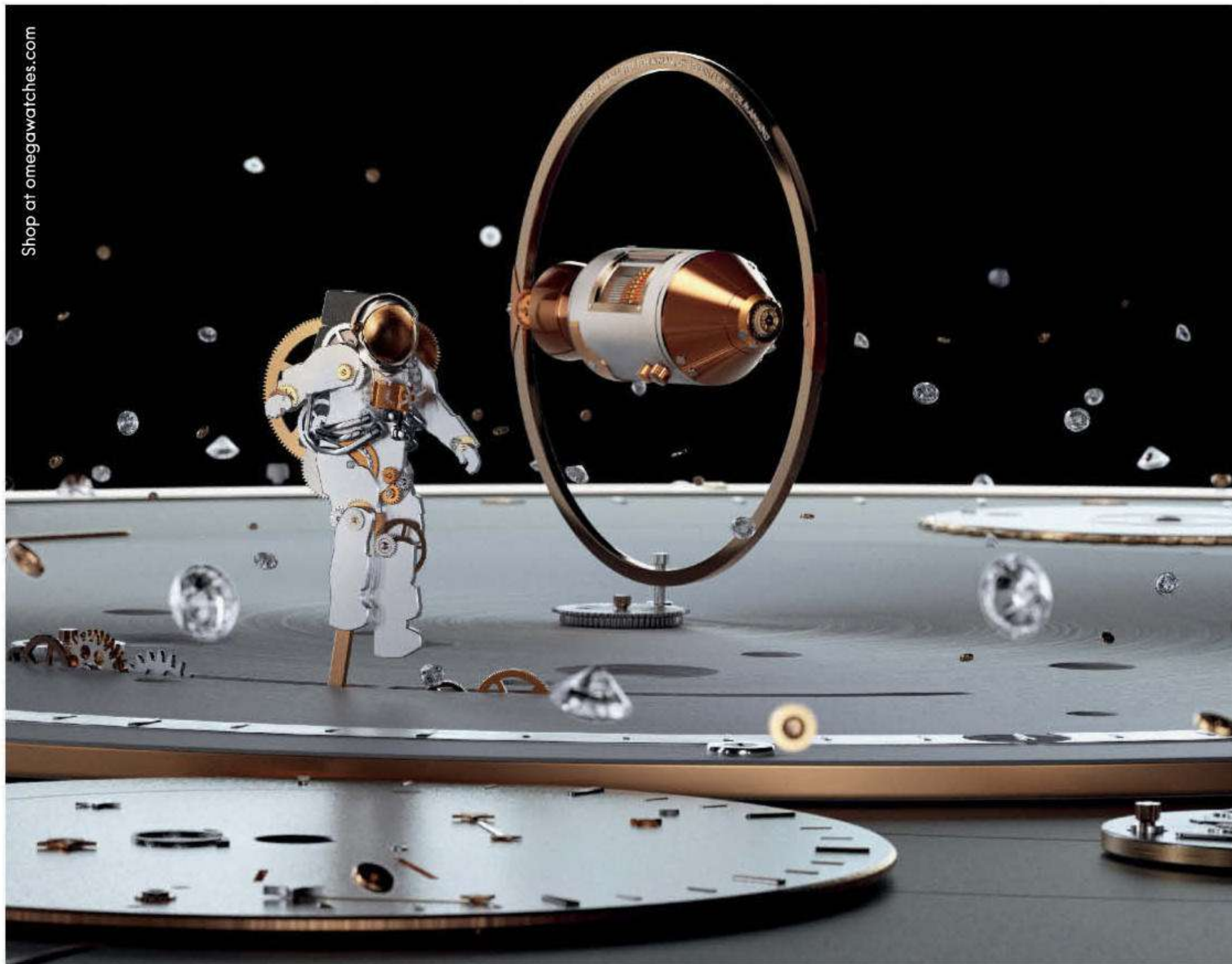
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